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THE CONSTITUTION OF NEBULÆ.

By Dr. H. SCHELLEN.[1]

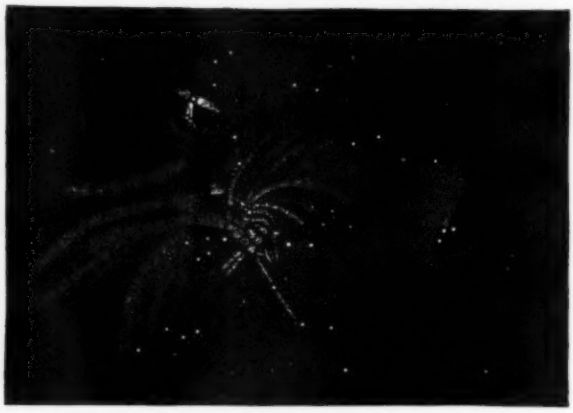
WHEN the starry heavens are viewed through a telescope of moderate power, a great number of stellar clusters and faint nebulous forms are revealed against the dark background of the sky which might be taken at first sight for passing clouds, but which, by their unchanging forms and persistent appearance, are proved to belong to the heavenly bodies, though possessing a character widely differing from the point-like images of ordinary stars. Sir William Herschel was able, with his gigantic forty-foot telescope, to resolve many of these nebulæ into clusters of stars, and found them to consist of vast groups of individual suns, in which thousands of fixed stars may be clearly separated and counted, but which are so far removed from us that we are unable to perceive their distance one from the other, though that may really amount to many millions of miles, and their light, with a low magnifying power, seems to come from a large, faintly-luminous mass. But all nebulæ were not resolvable with this telescope, and, in proportion as such nebulæ were resolved into clusters of stars, new nebulæ appeared which resisted a power of 6,000, and suggested to this astute investigator the theory that, besides the many thousand apparent nebulæ which reveal themselves to us as a complete and separate system of worlds, there are also thousands of real nebulæ in the universe composed of primeval cosmical matter out of which future worlds were to be fashioned.

Lord Rosse, by means of a telescope of fifty-two feet focus, of his own construction, was able to resolve into clusters of stars many of the nebulæ not resolved by Herschel; but there were still revealed to the eye, thus carried farther into space, new nebulæ beyond the power even of this gigantic telescope to resolve.

[1] Abridged from Schellen's "Spectrum Analysis."

Telescopes failed, therefore, to settle the question whether the unresolved nebulæ are portions of the primeval matter out of which the

FIG. 1.



THE GREAT NEBULA IN ORION.

existing stars have been formed; they leave us in uncertainty as to whether these nebulæ were masses of luminous gas, which in the lapse of ages would pass through the various stages of incandescent liquid

FIG. 2.

South.

North.

CENTRAL AND MOST BRILLIANT PORTION OF THE GREAT NEBULA IN THE SWORD-HANDLE OF ORION, AS OBSERVED BY SIR JOHN HERSCHEL IN HIS TWENTY-FOOT REFLECTOR AT FELDHAUSEN, CAPE OF GOOD HOPE (1834 TO 1837).

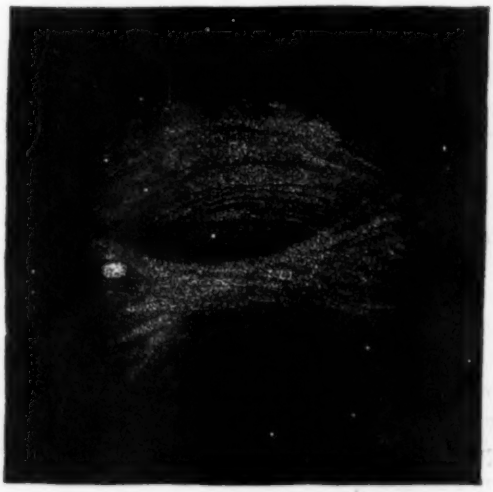
(the sun and fixed stars), of scoriæ or gradual formation of a cold and non-luminous surface (the earth and planets), and finally of complete gelation and torpidity (the moon), or whether they exist as a complete and separate system of worlds; telescopes have only widened the problem, and have neither simplified nor solved its difficulties.

That which was beyond the power of the most gigantic telescopes has been accomplished by that apparently insignificant, but really delicate, and almost infinitely sensitive instrument—the spectroscope; we are indebted to it for being able to say with certainty that luminous nebulæ actually exist as isolated bodies in space, and that these bodies are luminous masses of gas.

The splendid edifice already planned by Kant in his "Theory of the Heavens" (1755), and erected by Laplace forty-one years later, in his "System of the Universe," has received its topmost stone through the discoveries of the spectroscope. The spectroscope, in combination with the telescope, affords means for ascertaining even now some of the phases through which the sun and planets have passed in their process of development or transition from masses of luminous nebulæ to their present condition.

Great variety is observed in the forms of the nebulæ: while some are chaotic and irregular, and sometimes highly fantastic, others ex-

FIG. 2.



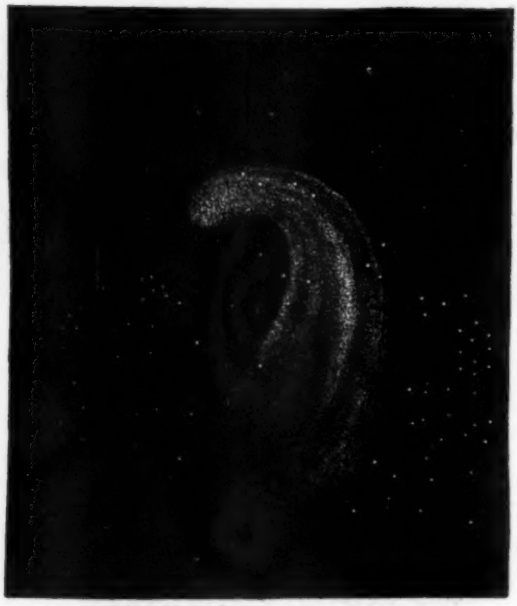
THE LARGE MAGELLANIC CLOUD.

hibit the pure and beautiful forms of a curve, a crescent, a globe, or a circle. A number of the most characteristic of these forms have been photographed on glass at the suggestion of Mr. Huggins; to these have been added a few others, taken from accurate drawings by Lord

Rosse; and they may all be projected on to a screen by means of the electric or lime-light lantern, and made visible to a large audience.

The largest and most irregular of all the nebulæ is that in the constellation of Orion (Figs. 1, 2). It is situated rather below the three stars of second magnitude composing the central part of that magnificent constellation, and is visible to the naked eye. It is extremely difficult to execute even a tolerably correct drawing of this nebula; but it appears, from the various drawings made at different times, that a change is taking place in the form and position of the brightest portions. Fig. 2 represents the central and brightest part of the

FIG. 4.



NEBULA OF THE FORM OF A SICKLE.

nebula. Four bright stars, forming a trapezium, are situated in it, one of which only is visible to the naked eye. The nebula surrounding these stars has a flaky appearance, and is of a greenish-white color; single portions form long curved streaks stretching out in a radiating manner from the middle and bright parts.

Much less irregularity is apparent in the great Magellanic or Cape clouds (Fig. 3), which are two nebulæ in the Southern Hemisphere, one of them exceeding by five times the apparent size of the moon. They are distinctly visible to the naked eye, and are so bright that they serve as marks for reconnoitring the heavens, and for reckoning the hour of the night.

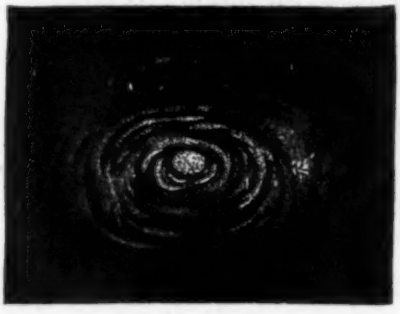
The interest aroused by these irregular and chaotic nebulous forms is still further increased by the phenomena of the spiral or convoluted nebulæ with which the giant telescopes of Lord Rosse and Mr. Bond have made us further acquainted. As a rule, there stream out from

Fig. 5.

Spiral Nebula in Canes Venatici.

one or more centres of luminous matter innumerable curved nebulous streaks, which recede from the centre in a spiral form, and finally lose themselves in space. Fig. 4 represents a nebula in the form of a sickle or comet-tail, and Fig. 5 shows the most remarkable of all the spiral nebulæ, situated in the constellation Canes Venatici.

Fig. 6.

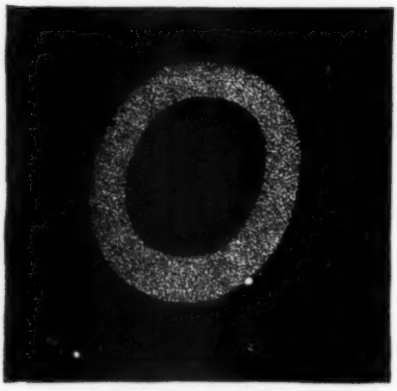


Transition from the Spiral to the Annular Form.

It is hardly conceivable that a system of such a nebulous form could exist without internal motion. The bright nucleus, as well as the streaks curving round it in the same direction, seems to indicate

an accumulation of matter toward the centre, with a gradual increase of density, and a rotatory movement. But, if we combine with this motion the supposition of an opposing medium, it is difficult to harmonize such a system with the known laws of statics. Accurate measures are, therefore, of the highest interest for the purpose of showing

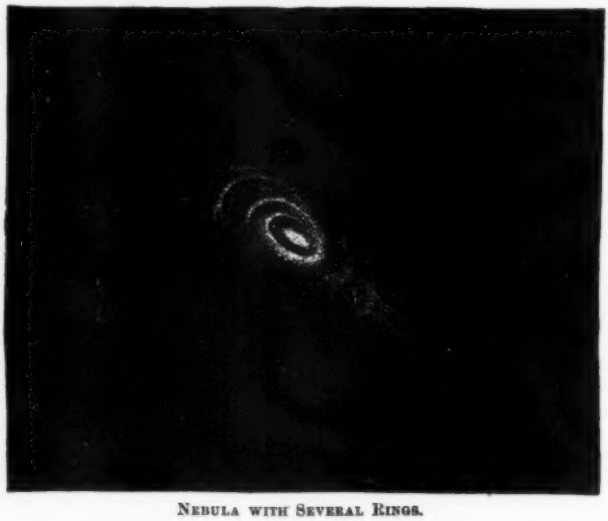
Fig. 7.



Annular Nebula in Lyra.

whether actual rotation or other changes are taking place in these nebulæ; but, unfortunately, they are rendered extremely difficult and uncertain by the want of outline, and by the remarkable faintness of these nebulous objects.

Fig. 8.



Nebula with Several Rings.

The transition state from the spiral to the annular form is shown in such nebulæ as the one represented in Fig. 6; and they then pass

into the simple or compound annular nebula of a type which is given in Fig. 7.

The space within most of these elliptie rings is not perfectly dark, but is occupied either by a diffused nebulous light, as in Fig. 7, or, as

FIG. 9.

ELLIPTICAL ANNULAR NEBULA.

in most cases, by a bright nucleus, round which sometimes one ring, sometimes several, are disposed in various forms. In Fig. 8 a representation is given of a compound annular nebula, with very elliptic rings and bright nucleus.

FIG. 10.

ELONGATED NEBULA.

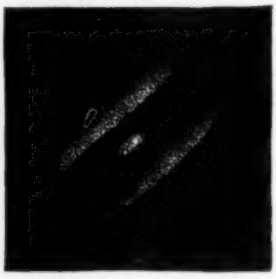
According as the ring has its surface or its edge turned toward us, or according as our line of sight is perpendicular or more or less obliquely inclined to the surface of the ring, its form approaches that

of a circle, a ring, an ellipse, or even a straight line. Nebulæ of this latter kind are represented in Fig. 9 and in Fig. 10. When an elliptical ring is extremely elongated, and the minor axis is much smaller than the major one, the density and brightness of the ring diminish as its distance from the central nucleus increases; and this takes place to such a degree sometimes, that at the farthest points of the ring, the ends of the major axis, it ceases to be visible, and the continuity seems to be broken. The nebula has then the appearance of a double nebula, with a central spot as represented in Figs. 11, 12.

FIG. 11.

DOUBLE NEBULA.

FIG. 12.



ANNULAR NEBULA WITH CENTRE.

Those nebulæ, which appear with tolerably sharply-defined edges in the form of a circle or slight ellipse, seem to belong to a much higher stage of development. From their resemblance to those planets which shine with a pale or bluish light, they have been called *planetary* nebulæ; in form, however, they vary considerably, some of them being

FIG. 13.

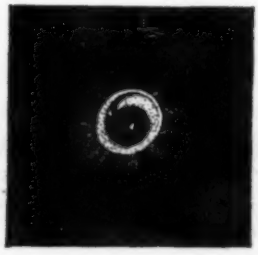
PLANETARY NEBULA WITH TWO STARS.

spiral and some annular. Some of these planetary nebulæ are represented in Figs. 12, 14, 15. The first has two central stars or nuclei, each surrounded by a dark space, beyond which the spiral streaks are disposed; the second has also two nuclei, but without clearly separable

dark spaces; the third is without any nucleus, but shows a well-defined ring of light.

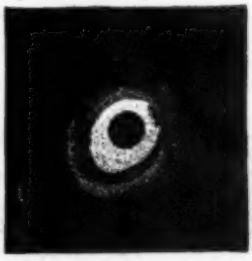
The highest type of nebulæ are certainly the stellar nebulæ, in which a tolerably well-defined bright star is surrounded by a completely rounded disk or faint atmosphere of light, which sometimes fades away gradually into space, at other times terminates abruptly with

FIG. 14.



PLANETARY ANNULAR NEBULA WITH TWO STARS.

FIG. 15.

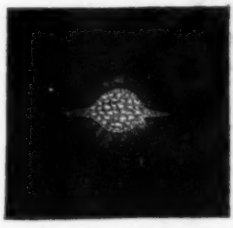


PLANETARY NEBULA.

a sharp edge. Figs. 16 and 17 exhibit the most striking of these very remarkable stellar nebulæ: the first is surrounded by a system of rings like Saturn, with the thin edge turned toward us; the second is a veritable star of the eighth magnitude, and is not nebulous, but is surrounded by a bright luminous atmosphere perfectly concentric. To the right of the star is a small dark space, such as often occurs in these nebulæ, indicating, perhaps, an opening in the surrounding atmosphere.

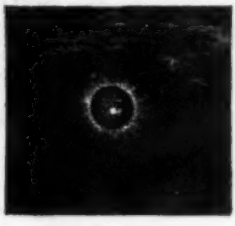
We have now passed in review all that is at present known of the nebulæ, so far as their appearance and form have been revealed by the largest telescopes. The information as yet furnished by the spectroscope on this subject is certainly much less extensive, but is neverthe-

FIG. 16.



PLANETARY NEBULA.

FIG. 17.

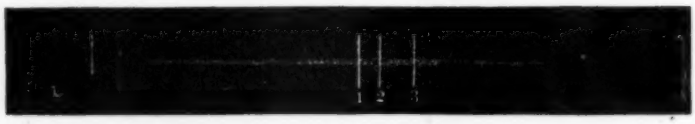


STELLAR NEBULA.

less of the greatest importance, since the spectroscope has power to reveal the nature and constitution of these remote heavenly bodies. It must here again be remembered that the character of the spectrum not only indicates what the substance is that emits the light, but also

its physical condition. If the spectrum be a *continuous* one, consisting of rays of every color or degree of refrangibility, then the source of light is either a *solid* or *liquid* incandescent body; if, on the contrary, the spectrum be composed of *bright lines* only, then it is certain that the light comes from *luminous gas;* finally, if the spectrum be continuous, but crossed by *dark* lines interrupting the colors, it is an indication that the source of light is a solid or liquid incandescent body, but that the light has passed through an atmosphere of vapors at a lower temperature, which by their selective absorptive power have abstracted those colored rays which they would have emitted had they been self-luminous.

FIG. 18.

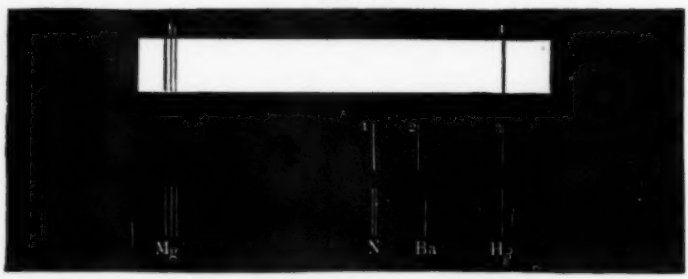


SPECTRUM OF NEBULA.[1]

When Huggins first directed his telescope in August, 1864, to one of these objects, a small but very bright nebula, he found, to his great surprise, that the spectrum, instead of being a continuous colored band, such as that given by a star, consisted only of *three bright lines.*

This one observation was sufficient to solve the long-vexed question, at least for this particular nebula, and to prove that it is not a cluster of individual, separable stars, but is actually a gaseous nebula, a body of luminous gas. In fact, such a spectrum could only be pro-

FIG. 19.



SPECTRUM OF NEBULA COMPARED WITH THE SUN AND SOME TERRESTRIAL ELEMENTS.

duced by a substance in a state of gas; the light of this nebula, therefore, was emitted neither by solid nor liquid incandescent matter, nor by gases in a state of extreme density, as may be the case in the sun and stars, but by luminous gas in a highly-rarefied condition.

In order to discover the chemical nature of this gas, Huggins followed the usual methods of comparison, and tested the spectrum with

[1] From Herschel's Catalogue, No. 4,374.

the Fraunhofer lines of the solar spectrum, and the bright lines of terrestrial elements. A glance at Fig. 19 will show at once the result of this investigation. The brightest line (1) of the nebula coincides exactly with the brightest line (N) of the spectrum of nitrogen, which is a double line. The faintest of the nebular lines (3) also coincides with the bluish-green hydrogen line Hβ, or, which is the same thing, with the Fraunhofer line F in the solar spectrum. The middle line (2) of the nebula was not found to coincide with any of the bright lines of the thirty terrestrial elements with which it has been compared; it lies not far from the barium line Ba, but is not coincident with it.

THE HYGIENE OF THE EAR.

By JAMES HINTON,
AURAL SURGEON TO GUY'S HOSPITAL, LONDON.

IT is natural that we should regard with an intense curiosity all the faculties with which our bodily frame is gifted, and that we should desire to preserve them as perfectly as possible. The following remarks are designed to do something toward gratifying that curiosity with regard to one of the most important of our powers, and to give a few hints in respect to things that are hurtful to it.

Our popular physiologies teach us that there is a tube leading from the drum of the ear into the throat, called, from its discoverer Eustachius, the "Eustachian tube." The use of this tube is twofold. First, it supplies the drum with air, and keeps the membrane exactly balanced, and free to move, with equal air-pressure on each side; and, secondly, it carries off any fluid which may be in the drum, and prevents it from being choked by its own moisture. It is not always open, however, but is opened during the act of swallowing, by a little muscle which is attached to it just as it reaches the throat. Most persons can distinctly feel that this is the case, by gently closing the nose and swallowing; when a distinct sensation is felt in the ears. This sensation is due to a little air being drawn out of the ears through the open tube during swallowing; and it lasts for a few minutes, unless the air is again restored by swallowing with the nose unclosed, which allows for the moment a free communication between the ear and the throat. We thus see a reason for the tube being closed. If it were always open, all the sounds produced in the throat would pass directly into the drum of the ear, and totally confuse us. We should hear every breath, and live in a constant bewilderment of internal sounds. At the same time the closure, being but a light contact of the walls of the tube, easily allows a slight escape of air *from* the drum, and thus not only facilitates and regulates the oscillations of the air before the

vibrating membrane, but provides a safety-valve, to a certain extent, against the injurious influence of loud sounds.

The chief use of the Eustachian tube is to allow a free interchange of air between the ear and the throat, and this is exceedingly important; and it is very important also that its use in this respect should be understood. Persons who go down in diving-bells soon begin to feel a great pressure in the ears, and, if the depth is great, the feeling becomes extremely painful. This arises from the fact that in the diving-bell the pressure of the air is very much increased, in order to balance the weight of the water above; and thus it presses with great force upon the membrane of the drum, which, if the Eustachian tube has been kept closed, has only the ordinary uncompressed air on the inner side to sustain it. It is therefore forced inward and put upon the stretch, and might be even broken. Many cases, indeed, have occurred of injury to the ear, producing permanent deafness, from descents in diving-bells, undertaken by persons ignorant of the way in which the ear is made; though the simple precaution of frequent swallowing suffices to ward off all mischief. For, if the Eustachian tube is thus opened, again and again, as the pressure of the outside air increases, the same compressed air that exists outside passes also into the inside of the drum, and the membrane is equally pressed upon from both sides by the air, and so is free from strain. The same precaution is necessary in ascending mountains that are lofty, for then there is the same effect of stretching produced upon the membrane, though in the opposite way. The outside air becoming less and less condensed as a greater height is gained, the ordinary air contained within the drum presses upon the membrane, which is thus insufficiently supported on the outside, and a similar feeling of weight and stretching is produced. The conjurer's trick of breaking a vase by a word rests on the same principle. The air is exhausted from within, and the thin, though massive-looking sides of the vase collapse by the pressure of the air outside; and, just as ever so small a hole, made at the right moment in the side of the vase, would prevent the whole effect, so does swallowing, which makes a little hole, as it were, for the moment in the drum of the ear, prevent the in-pressing or out-pressing of the membrane. Mr. Tyndall, in his interesting book "On Sound," tells us how he employed this precaution of swallowing, and with entire success, when, in one of his mountain excursions, the pressure on his ears became severely painful.

Deafness during colds arises very often, though not always, from a similar cause. For, when, owing to swelling of the throat, the Eustachian tube cannot be opened by its muscle, and so the air in the drum is not renewed, the air that is contained in it soon diminishes, and the outer air presses the membrane in, so that it cannot vibrate as it should. This is what has been sometimes called "throat-deafness."

There are several things very commonly done which are extremely

injurious to the ear, and ought to be carefully avoided. Those who have followed the previous description will easily understand the reason.

And first, children's ears ought never to be boxed. We have seen that the passage of the ear is closed by a thin membrane, especially adapted to be influenced by every impulse of the air, and with nothing but the air to support it internally. What, then, can be more likely to injure this membrane than a sudden and forcible compression of the air in front of it? If any one designed to break or overstretch the membrane, he could scarcely devise a more effective means than to bring the hand suddenly and forcibly down upon the passage of the ear, thus driving the air violently before it, with no possibility for its escape but by the membrane giving way. And far too often it does give way, especially if, from any previous disease, it has been weakened. Many children are made deaf by boxes on the ear in this way. Nor is this the only way: if there is one thing which does the nerve of hearing more harm than almost any other, it is a sudden jar or shock. Children and grown persons alike may be entirely deafened by falls or heavy blows upon the head. And boxing the ears produces a similar effect, though more slowly and in less degree. It tends to dull the sensibility of the nerve, even if it does not hurt the membrane. I knew a pitiful case, once, of a poor youth who died from a terrible disease of the ear. He had had a discharge from it since he was a child. Of course his hearing had been dull: and what had happened was that *his father had often boxed his ear for inattention!* Most likely that boxing on the ear, diseased as it was, had much to do with his dying. And this brings me to the second point. Children should never be blamed for being inattentive, until it has been found out whether they are not a little deaf. This is easily done by placing them at a few yards' distance, and trying whether they can understand what is said to them in a rather low tone of voice. Each ear should be tried, while the other is stopped by the finger. I do not say that children are never guilty of inattention, especially to that which they do not particularly wish to hear; but I do say that very many children are blamed and punished for inattention when they really do not hear. And there is nothing at once more cruel and more hurtful to the character of children than to be found fault with for what is really their misfortune. Three things should be remembered here: 1. That slight degrees of deafness, often lasting only for a time, are very common among children, especially during or after colds. 2. That a slight deafness, which does not prevent a person from hearing when he is expecting to be spoken to, will make him very dull to what he is not expecting; and, 3. That there is a kind of deafness in which a person can hear pretty well while listening, but is really very hard of hearing when not listening.

The chief avoidable cause of deafness is catching cold, and what-

ever keeps us from colds helps us to preserve our hearing. We should do, therefore, those things that help to keep colds away: for which the first is taking plenty of fresh air; the second using enough, but not too much, cold water all over us, taking especial care to rub ourselves thoroughly dry, and never to let it chill us; and the third is to avoid draughts, and wet, especially sitting in wet clothes, or being in close or very heated rooms. But there are some kinds of cold especially hurtful to the ear. One is sitting with the ear exposed to a side wind, as too many people do now on the roofs of omnibuses, and so on. We should always *face* the wind; then, if we are not chilled, it is hard to have too much of it. Another hurtful thing is letting rain or sleet drive into the ear, against which, if it were not that people do sometimes suffer from this cause, it would seem as if it could hardly be necessary to caution them.

Another source of danger to the ear, however, arises from the very precautions which are sometimes taken against those last mentioned. Nothing is more natural than to protect the ear against cold by covering it by a piece of cotton-wool; and this is most useful if it is done only on occasions of special exposure, as when a person is compelled to encounter a driving storm, or has to receive on one side of the head the force of a cutting wind. But it is astonishing in how many cases the cotton-wool thus used, instead of being removed from the ear when the need for it has passed, is pushed down into the passage, and remains there, forming itself an obstruction to hearing, and becoming the cause of other mischiefs. Three separate pieces have sometimes been found thus pushed down, one upon the other. Paper rolled up, which is also used for protecting the ear when cotton-wool is not at hand, is still more irritating when it is thus left unremoved. The way to avoid this accident, besides being careful not to forget, is to use a large piece of wool, and to place it over, rather than in, the passage.

It should be remembered that constantly covering up the ear is adapted to injure it. On the whole, men in whom the ear is habitually exposed, suffer if any thing less from ear-disease than women, in whom it is so often covered. Nor can the "hat" be held an unsafe head-dress in this respect for the latter sex. But it is important that there should not be frequent changes, especially in cold weather, from a head-dress which covers to one which exposes the ear. It is better that the air should always have free access to it; but if this has not been the case, the summer should be chosen to make the change.

All sorts of substances are sometimes put into the ear by children, who do it to themselves or to each other in ignorant play. If every parent and teacher warned his children against doing this, it would not be a useless precaution. When the accident happens, the chief danger is that of undue haste and violence. Such bodies should be removed by syringing with warm water alone, and no attempt should be made to lay hold of them or move them in any other way. It is enough to

reflect, again, that the passage of the ear is closed by a delicate membrane to show the reason for this rule. When no severe pain follows, no alarm need be felt. It is important that the substance should be removed as speedily as is quite safe, but there need never be impatience; nor should disappointment be felt if syringing needs to be repeated on many days before it effects its end. It will almost invariably succeed at last in the hands of a medical man, and is most effective if the ear is turned downward and syringed from below.

Now and then an insect gets into the ear and causes great pain; the way to get rid of it is to pour oil into the ear. This suffocates the insect.

There is another danger arising from boyish sports. Snowballs sometimes strike the ear, and the snow remaining in it sets up inflammation. This danger is increased by a practice which should be inadmissible, of mixing small stones with the snow, which thus effect a lodgment in the ear.

Among the causes of injury to the ear must unfortunately be reckoned bathing. Not that this most healthful and important pleasure need, therefore, be in the least discouraged; but it should be wisely regulated. Staying too long in the water certainly tends to produce deafness as well as other evils; and it is a practice against which young persons of both sexes should be carefully on their guard. But, independently of this, swimming and floating are attended with a certain danger from the difficulty of preventing the entrance of water into the ear in those positions. Now, no *cold* fluid should ever enter the ear; cold water is always more or less irritating, and, if used for syringing, rapidly produces extreme giddiness. In the case of warm water its entrance into the ear is less objectionable, but even this is not free from disadvantage. Often the water lodges in the ears and produces an uncomfortable sensation till it is removed: this should always be taken as a sign of danger. That the risk to hearing from unwise bathing is not a fancy, is proved by the fact, well known to lovers of dogs, that those animals, if in the habit of jumping or being thrown into the water, so that their heads are covered, frequently become deaf. A knowledge of the danger is a sufficient guard. To be safe it is only necessary to keep the water from entering the ear. If this cannot be accomplished otherwise, the head may be covered. It should be added, however, that *wet hair*, whether from bathing or washing, may be a cause of deafness, if it be suffered to dry by itself. Whenever wetted, the hair should be wiped till it is fairly dry. Nor ought the practice of moistening the hair with water, to make it curl, to pass without remonstrance. To leave wet hair about the ears is to run great risk of injuring them. In the washing of children, too, care should be taken that all the little folds of the outer ear are carefully and gently dried with a soft towel.

But I come now to what is probably the most frequent way in which

the ear is impaired: that is, by the attempt to clean it. It ought to be understood that the passage of the ear does not require cleaning by us. Nature undertakes that task, and, in the healthy state, fulfils it perfectly. Her means for cleansing the ear is *the wax*. Perhaps the reader has never wondered what becomes of the ear-wax. I will tell him. It dries up into thin fine scales, and these peel off, one by one, from the surface of the passage, and fall out imperceptibly, leaving behind them a perfectly clean, smooth surface. In health the passage of the ear is never dirty; but, if we attempt to clean it, we infallibly make it so. Here—by a strange lack of justice, as it would seem, which, however, has no doubt a deep justice at the bottom—the best people, those who love cleanliness, suffer most, and good and careful nurses do a mischief negligent ones avoid. Washing the ear out with soap and water is bad; it keeps the wax moist when it ought to become dry and scaly, increases its quantity unduly, and makes it absorb the dust with which the air always abounds. But the most hurtful thing is introducing the corner of the towel, screwed up, and twisting it round. This does more harm to ears than all other mistakes together. It drives down the wax upon the membrane, much more than it gets it out. Let any one who doubts this make a tube like the passage, especially with the curves which it possesses; let him put a thin membrane at one end, smear its inner surface with a substance like the ear-wax, and then try to get it out so by a towel! But this plan does much more mischief than merely pressing down the wax. It irritates the passage, and makes it cast off small flakes of skin, which dry up, and become extremely hard, and these also are pressed down upon the membrane. Often it is not only deafness which ensues, but pain and inflammation, and then matter is formed which the hard mass prevents from escaping, and the membrane becomes diseased, and worse may follow. *The ear should never be cleaned out with the screwed-up corner of a towel.* Washing should extend only to the outer surface, as far as the finger can reach.

Ear-picks, again, are bad. If there is any desire to use them, it shows that the ear is unhealthy; and it wants soothing, not picking. And there is another danger from introducing any solid thing into the ear. The hand may get a push, and it may go too far. Many is the membrane that has thus been broken by a bodkin. Sportsmen sometimes have their membrane pierced by turning suddenly while getting through a hedge. And it even happens that a boy at school may put a pen close to another's ear, in play, and call to him to make him turn his head; and the pen pierces the membrane. Very loud sounds may cause deafness, too. Artillerymen, and also eager sportsmen, and very zealous volunteers, incur a danger from this cause. It is well to stop the ears when exposed to loud sounds, if possible; also to avoid belfries when the bells are about to ring. A man who was once shut up in one became stone-deaf before the peal was done. The sound of guns

is more injurious to those who are in a confined space with them, and also if the mouth be open. Injury from loud sounds, also, is much more likely to occur if they are unexpected; for, if they are anticipated, the membrane is prepared for them, without our knowledge, by its muscles. At certain points on the Rhine, it is, or was, the custom of the captain of the steamboat to fire a small cannon, to exhibit the echo. When this has been done without due warning, it has proved more than once a cause of lasting deafness. Sometimes these loud sounds rupture the membrane; sometimes they deaden the nerve: the former is the least evil.

It is a bad practice, also, to put cotton-wool soaked in laudanum or chloroform into the ear for the relief of toothache. It may be sometimes effectual, for the nervous connection between the teeth and the ear is very close. But the ear is far too delicate and valuable an organ to be used as a medium for the application of strong remedies for disorders of other and less important parts; and laudanum, and more especially chloroform, is a powerful irritant. The teeth should be looked after in and for themselves, and, if toothache spreads to the ear, that is the more reason for taking them thoroughly in hand; for prolonged pain in the head, arising from the teeth, may itself injure the hearing. When a child's ear becomes painful, as it so often does, every thing should be done to soothe it, and all strong, irritating applications should be avoided. Pieces of hot fig or onion should not be put in; but warm flannels should be applied, with poppy-fomentation, if the pain does not soon subside. How much children suffer from their ears, unpitied because unknown, it would probably wring the hearts of those who love them suddenly to discover. It is often very hard, even for medical men, to ascertain that the cause of a young child's distress is seated in the ear, and frequently a sudden discharge from it, with a cessation of pain, first reveals the secret of a mysterious attack which has really been an inflammation of the drum. The watchfulness of a parent, however, would probably suffice to detect the cause of suffering, *if directed to this point*, as well as to others. If children cry habitually when their ears are washed, that should not be neglected; there is, most likely, some cause of pain. Many membranes are destroyed from discharges which take place during "teething." Whenever there is a discharge of matter from the ear, it would be right to pour in warm water night and morning, and so at least to try and to keep it clean. But into the treatment of diseases of the ear it would not be suitable to enter here.—*Abridged from the People's Magazine.*

ECONOMY OF RAILWAY LOCOMOTION.

By J. W. GROVER, C. E.

THE primary conception of a railway is a perfectly smooth, level, and straight road, upon which friction is reduced to the minimum, so that heavy loads may be propelled with the least possible resistance, and at the highest rate of speed.

The earliest type of locomotive-engine was designed to run upon such straight and level roads, and it was supposed for many years that locomotives could not climb hills, or be made to go round corners.

The first railway-carriages were a simple modification of the stage-coaches, names and all. It is interesting to look at the curious three-bodied "Marquis of Stafford"—with yellow panels and windows, filled with ladies in large coal-scuttle bonnets—as shown in one of Ackermann's early engravings of the Liverpool and Manchester Railway, the only substantial difference being that, inasmuch as the railways of those days were made nearly straight, no arrangement was provided for allowing the axles of the carriage to radiate as they do partially in common road-vehicles, but both axles were rigidly fastened so as to be immovable.

Again, as all road-vehicles have to turn abrupt corners, their wheels are made to turn independently upon their axles, but, so soon as flanges were employed to keep the wheels of the railway-carriages between two straight rails, this arrangement was found unnecessary, and, to obtain greater strength and security, the wheels were rigidly fastened to the axle, and both were compelled to revolve together.

Now, since the primary conception of the perfectly smooth, straight road, a great degeneracy has been of necessity taking place; with greatly increased demands, less capital than ever has been forthcoming; consequently the great cuttings and embankments of early days are being abandoned as precedents, and it becomes necessary that railways should approach more closely to the form of ordinary roads, which follow the surface of the ground only, at small cost.

Hence it follows that the rolling-stock itself must revert more nearly to its original pattern, readopting those contrivances which, under altered circumstances, were discarded.

Let us keep to the most elementary principles, for it is these which are forgotten and misunderstood, and yet should be engraven on brass and hung up in every railway board-room in the world. On a common road, a horse can pull a ton weight in a cart behind him on the level at 4 to 4¼ miles an hour, or, which is the same thing, if a weight of 70 lbs. were hung over a pulley and lowered down a well, he could pull it up at the speed mentioned. It is necessary to be a

little explicit, as the remarks in this paper are intended for non-technical readers particularly. Now, if two strips of iron called rails are laid upon the aforesaid road, the friction is reduced sevenfold; that is to say, the same horse at the same speed could draw 7 tons, the difference between macadam and iron being as 70 lbs. to 10 lbs. This immense advantage, however, disappears when gradients have to be encountered, because the resistance due to gravity becomes so greatly in excess of the resistance due to friction, and is constant in both cases. For instance, if on a common road, up a slope of one foot in ten, the horse takes 5 cwt. in a cart over the macadam, if rails be laid down up the same hill, he could only increase the burden behind him by a little more than 1 cwt., or, in all, 6¼ cwts.; hence, in this case, the value of the rails is nearly lost. Hence the small use of tramways where hills occur.

Upon a very good macadamized road the resistance due to friction is usually taken at about *one-thirtieth* of the whole load carried; that is to say, if the vehicle were put upon a road sloping 1 in 30, it would just begin to move of itself. But, upon a railway, under the most favorable conditions, the resistance due to friction has been reduced to the *two-hundred-and-eightieth* part of the whole load carried; that is to say, the vehicle will begin to move of itself on a gradient of 1 in 280. In considering the work which a horse can perform on a tramway, it is important to bear in mind the question of speed; for, according to the experiments of Tredgold, he can draw exactly four times as much at two miles an hour as he can at five, and it appears that, at three miles an hour, he does the greatest amount of actual useful work, whereas, at ten miles an hour, only one-fourth of his actual power is available, and he cannot exert that for an hour and a half; whereas, at two and a half miles an hour, he can continue working for eight hours. Having these data before us, it is easy to compare the values of steam and horse-flesh: Suppose coals to cost in the midland districts 18*s.* 8*d.* a ton only, or one-tenth of a penny per pound, and, assuming that an average locomotive-engine will not consume more than 5 lbs. of coal in the hour per horse-power, the cost of fuel per horse-power will be a halfpenny per hour. Taking the value of the horse's provender at 1*s.* 9*d.* a day only, and supposing he works for six hours, that would cost 3½*d.* an hour against a halfpenny in the case of steam, or, as 7 to 1 in favor of steam; and this result is obtained on the supposition that the horse travels only at three miles an hour.

Now, to sum up the combined advantages, therefore, of an engine on a level railway against a horse on a level common road at 10 miles an hour, we shall find that the former gives an economy over the latter of nearly 300 to 1; at 5 miles an hour, it would stand as 115 to 1; and, at 2½ miles an hour, as 64 to 1.

Such are the enormous advantages of *steam and rails*, and with them does it not seem astonishing that better financial results have

not been obtained? There must be something wrong somewhere. As Artemus Ward says, "Why is this thus, and what is the reason of this thusness?"

Speed is the delinquent, and the cause of the loss of the great primary advantages: the vehicles on railways are propelled very fast; hence they involve great strength in their construction, and enormous weight in proportion to the paying load carried.

An old stage-coach, according to Nicholas Wood, weighed only 16 to 18 cwts., and would carry upward of 2 tons of paying passengers with their luggage, or about $\frac{4}{10}$ of a hundred-weight of dead load to every hundred-weight of paying load. Now, a third-class carriage with four compartments would represent 2.8 cwts. of dead weight to every 1 cwt. of paying load. Therefore, the stage-coach has the advantage over the third-class railway-carriage of $6\frac{1}{2}$ to 1.

It becomes impossible to institute any absolute comparison between roads and railways at speeds above 10 miles an hour, because such speeds are impossible on the former for any considerable distance. Again, the question of a gradient has to be noticed, for in the preceding remarks a level road and a level railway have only been considered.

As has been explained, where steep gradients occur, the resistance due to gravity so much outweighs that due to friction that rails afford a comparatively insignificant advantage, and one which is entirely lost if the stock has to be increased in weight $6\frac{1}{2}$ times.

It may easily be shown that, on a gradient of 1 in 10, for instance, taking the foregoing figures, the advantages of a steam-worked railway over a horse-worked road would be little more than one-fourth, if the stock on the former be only $6\frac{1}{2}$ times heavier in proportion than the latter would require. Hence it follows that no railway having gradients of 1 in 10 could be worth making (assuming such to be possible) unless the stock upon it were assimilated to that of the ordinary omnibus or stage-coach type.

In former times calculations were made by Nicholas Wood of the comparative costs of conveyance on ordinary roads by horses; he showed that on an average a stage-wagon could carry at the rate of $2\frac{1}{2}$ miles an hour profitably at 8*d.* a ton per mile; that a light van or cart at 4 miles an hour could take for 1*s.* a mile a ton of goods. Passengers in stage-coaches were charged 3*d.* a mile each, or 3*s.* 6*d.* a ton, at 9 miles an hour. Now, let us consider what railways actually do. At the present moment coals are conveyed at $\frac{5}{8}d.$ per ton per mile, at an average speed of 20 miles an hour; and this low rate actually leaves a profit. Excursion-trains take passengers at less than $\frac{1}{2}d.$ each per mile, at twenty miles an hour, or at 7*d.* a ton a mile.

Now, bearing in mind the relative proportions of paying and non-paying loads involved in carrying passengers and coals, a simple calculation will show that a ton of passengers could be carried for

something less than 1*d.* a mile, or $\frac{1}{14}$ part of a penny each. For, although passengers require station accommodation, they unload themselves, which coals do not.

In the autumn of 1869, the *Times* took up the railway problem, and, in a series of very able articles, endeavored to show the errors of the present state of things. Although advocated by so powerful a pen, the reforms still remain unaccomplished—indeed, uncommenced. It was then shown that in practice every passenger on a railway involved over 2 tons—of iron and timber—to carry him. Or, according to Mr. Haughton, no more than 30 per cent. of the load which is hauled by a goods-train represents paying weight, the remaining 70 per cent. being dead weight. This seems astonishing truly, but it is nothing to the passenger-trains, where only 5 per cent., or even less, of the load pays, the remaining 95 per cent. being made up of apparently dead and unprofitable material. It is well to keep this clearly in view. In talking about a passenger, with relation to a railway, one must not picture to one's self a respectable English country gentleman, riding perhaps some 14 stone, but some Homeric giant, magnified into prehistoric proportions, weightier than an ordinary Ceylonese elephant, and representing about 20 to 25 full sacks of coal, or 2¼ tons.—*Abstract from Quarterly Journal of Science.*

INSTINCT IN INSECTS.

By GEORGE POUCHET.

TRANSLATED BY A. R. MACDONOUGH, ESQ.

II.

LET us now dwell a little on two grand facts presented to us by the animated world, these two properties of living beings equally undeniable and unintelligible in their essence—habit, and hereditary tendency; and let us see how, in Darwin's theory, they will combine with intelligence. As the theory is well known, we need not state it. Cuvier believed in the unchangeableness of the animal forms placed on the globe by the Creator after each of the great convulsions through which, as he held, our planet has passed. Modern geology questions these violent commotions, and Darwin, taking up in his turn Lamarck's ideas, after fifty years of scientific progress, maintains, by almost irresistible arguments, that animal forms, instead of being unchangeable, as Cuvier supposed, are slowly modified, under the control of time, of circumstances, and of the energies with which each individual and each race "fight the battle of existence." That individual which brings into life a slight yet advantageous modification of its organs will suc-

ceed better in life than another. It will have every chance, then, of leaving a more numerous posterity. If the advantageous modification is transmitted, which may occur through hereditary tendency, the descendants of this individual will have, in their turn, the chance of succeeding better than their contemporaries. The modification, then, in all probability, will go on becoming more general, by the same law of fatality that causes a strong people to absorb a weak one: so that, after a longer or shorter time, the whole race will end by presenting the modification which was only individual at the outset. And since there was no reason why the same phenomenon, so natural and so simple, should not be repeated indefinitely, with all imaginable variations, we understand how it may result, in the infinite lapse of time, in that multiplicity of forms and characters which distinguishes animal species to our eyes.

Darwin says, in those pages in which he treats of instinct, that, if it were possible to prove that a habit might become hereditary, all distinction between habit and instinct would absolutely vanish. Darwin's literary procedure is that of always urging his reader further than he seems to go himself. He suggests the best arguments in the world with a doubtful air, and one is every moment surprised to find one's self so strongly convinced when the author seems convinced so little. And, in fact, we cannot deny that young puppies often come to a point the very first time they are sent out hunting, and that even better than others after long training. The habit of saving life is hereditary in some breeds, just as the shepherd's dog has the habit of walking around the flock. All these acts are performed, without the aid of experience, by the young as well as the old, and certainly apart from any notion of the object—at the first time, at least. The objection is idle that only those habits imposed by men on brutes are transmitted in this way. More than one instance, taken from wild animals, proves the contrary. The best is perhaps that which we see done by a bird of our own country, the oriole. It has a very peculiar cradle-shaped nest, hung from the fork of a branch, sewed at the edges with flexible grass, and always with bits of string, shreds, or packthread. There is no oriole's nest without some fastening worked by man's hand. If this is a habit, it is hereditary; if it is an instinct, it will be admitted at least that it does not go back to the beginning of the world.

From birth, one individual, or several individuals of the same species, placed in similar conditions, have had some habit. One of two things: this habit is injurious, or it is useful; it is either good or bad, from the point of view of the preservation of the individual, and consequently of the species. If it is injurious, it necessarily tends to disappear, either with the individual which has taken it on, or with the descendants which will inherit from it. If the habit is favorable, it has the chance of transmitting itself under the form of an instinct. This instinct, at first confined to a few individuals of the same blood,

tends to become general, since it is advantageous, and we thus fall back into a particular case of the great principle of natural selection formulated by Darwin. Let us go on. Thus far this instinct is but little complicated, since it has only the significance of a habit that one individual may have been able to take up with its share of intelligence. Now that it is seen rooted under the form of instinct, each individual in its turn, with its own share of intelligence, may be able to add something to it of its own accord. If that addition is still favorable, and again gets transmitted, it will tend in the same way to become general; the acquired instinct will grow so much the more complex; and, exactly as organic modifications scarcely perceptible, but accumulated successively, to a sufficient number, have been able to multiply animal forms infinitely, so instinct, by almost imperceptible but continuous additions, may be able to end by reaching that state of perfection in which philosophers had supposed they saw the convincing proof of a preëstablished harmony.

Some naturalists even now are not, very fortunately, inspired when they attempt to prove to us that the corporeal organization of every animal is conceived and framed with regard to its instincts. We need not go far to learn, as indeed we might expect from what has gone before, that instinct is in many cases independent of external forms. All birds, whether they are masons, like the swallow; weavers, like the warbler; carpenters, like the crow; mound-builders, like the *mégapode* —have the same beak, the same claws, and forms almost the same. The European beaver, inhabiting the affluents of the Rhone and the Danube, is scarcely to be distinguished from the American beaver, yet he has quite a different kind of work to do. The American beaver, on his lakes and great, lonely rivers, builds the famous houses so well known; the European beaver burrows long galleries underground in the manner of moles. If he has always done so, what becomes of that supposed necessary correlation between the organs and the instinct of a burrowing animal on one continent, a building animal on the other, with the same members for two objects so different? If the European beaver did once build huts, where shall we find more decisive testimony in favor of the theory of mutability in instincts? Pursued for his warm covering and his flesh, he has changed his instincts, before invading civilization, more rapidly than his external form. It is a point well established at this day that the contact with man has had a decisive effect on the instinct of many animals. It is thus that in inhabited countries large birds take flight at his approach, while they still allow him to come close to them in countries visited by travellers for the first time. Wherever they have been hunted like a prey that is worth the trouble of pursuit for their flesh or their feathers, they have formed the habit, and then have had the instinct of taking flight.

Let us return to insects. Two instincts, the most remarkable among all, are presented by them; that of the bee, with its mathematical

architecture, and that of the ant, with its mixed societies. Before inquiring whether it might not be possible to explain even such amazing instincts by habit and inherited tendency, it is important at the outset to remove an objection that might be supposed unanswerable. Those individuals that have these instincts in the hive or in the ant-hill are neuters—that is to say, they are neither male nor female, and must consequently die without posterity. How explain the way in which a habit acquired by a neuter can be transmitted, can grow into an instinct, in the neuters of following generations, which will not descend from that first one? Yet the difficulty is not so great as it seems, and Darwin points it out very well. Indeed, it is not the instincts of the neuters which concern him, but it is the special organic modifications that these present, in connection with their social duties—with some, labor, and with others, fighting; but the reasoning he employs can be applied as well to instincts, behind which there always appears, as we see by a little reflection, that latent modification of the cerebral organ through which the transmission has taken place.

Darwin begins with a reminder that the principle of natural selection is true as well for communities as for individuals. The strength of a single male in a wild herd, the extraordinary fecundity of a single female, will be the elements of prosperity. The herd will succeed better than the rest. The qualities of the individual from which it draws its advantage will have a chance of being transmitted at first to all the herd, and this, more and more favored in the struggle against the outer world, will absorb the rest. The modification, at first individual, will become general. It would be the same if the member of the herd benefited in the beginning had been a neuter. We are still speaking of external forms. Let us suppose that a certain number of neuters may have brought from birth a favorable organic modification into a community of insects, and that by this the community has prospered; the males and females who have produced these neuters will then have, by them, the greatest possible chances of posterity. It may happen thenceforward that they transmit to their descendants what they had themselves—that is to say, the property of procreating neuters having the same favorable organic modification—and we thus fall back into the common process of natural selection. Such is Darwin's explanation; he is well aware, when he gives it, complex as it is, that it is the touchstone of his theory, the side whence attack will come; therefore, how he strengthens his arguments! He is no longer satisfied with explaining, he demonstrates; he is supposed to have exhausted his reasons, and this is the very moment he chooses for an appeal to experiment, and to the proof of that kind of paradox that might be called "hereditary tendency in sterility." There are oxen with horns a little longer than those of the bulls and heifers that produced them. "Well," says Darwin, "pair together, by attentive selection, the fertile descendants of the bulls and heifers that produced the oxen with longer

horns, and before long you will have a race of oxen in which length of horns will be hereditary, although the animal is sterile." The experiment has yet to be made, and is worthy of being a temptation to some one of the great English lords who know so well how to spend their fortunes for the advance of science. There is every reason to believe that it would succeed; and, if this striking instance ever comes, to justify Darwin's theories in their points most difficult of explanation, how can we avoid accepting them in their completeness, as well for external forms as for instinct?

Neuters in a community bring at their birth an intellectual disposition, a special tendency. The community benefits by it, and prospers; but the parents of these neuters have produced, besides, males and females, who will be able to inherit in their turn the property of giving life to neuters having the same disposition or the same tendency with the first. This becomes hereditary; it fixes itself in the race; it is thenceforward an instinct; and it will be able to continue developing itself thus by a sort of collateral inheritance. The source of it will continue in the parents without its being necessary that they should have it themselves, exactly as the reason for the long horns of the oxen is in the parent bull and heifer which have only short ones themselves.

Even after confuting this great objection of the neuters, the problem of explaining the architecture of bees by natural conditions seemed still to defy every attempt. Yet Darwin undertook to solve it. Aided by the experiments of his countryman Waterhouse, he shows that all this labor, worthy of the most practised geometrician, can be reduced, in the last analysis, to a certain number of very simple habits, taken in succession, so that by a linking together of facts, hypothetical, it is true, yet all perfectly plausible and possible, we arrive at the discovery, in the biological laws already known, of a natural explanation of that instinct which seems to share in the miraculous. We know the subject in question. The cells of the bee are six-sided prisms of perfect regularity. The most interesting point is the bottom of the cell; it is formed of a hollow pyramid of three equal sides, and arranged in such a manner that each contributes its share, on the other side of the comb, to make the bottom of a distinct cell; the bottom of each cell thus rests on three cells on the other side of the comb. Buffon did not remark this combination; he only spoke of the regular hexagonal design of the whole, and on this subject he had a singular idea. "The bees," he said, "all want to make a cylindrical chamber for themselves in the wax, but room is wanting; on the comb, which is too small, each one attempts to settle itself in the way most convenient for itself, at the same time that all are equally in each other's way. The cells are hexagonal only on account of reciprocal obstacles. For the same reason," he adds, "as, if we fill a vessel with peas or cylindrical grains, shut it tightly after pouring in as much water as the

intervals between these grains can receive, and set the water boiling, all these cylinders will become six-sided columns." Buffon's comparison has been a good deal laughed at, yet it is not altogether bad. He understood that each cell with its sides cut at regular angles was not an individual work, nor the direct execution of the original plan; that it was a kind of resultant brought about by the forced neighborhood, the mutual crowding and hindering of constructions conceived on a simpler plan, and one more usual among insects, the cylindrical chamber.

The humble-bees, which are hymenopterous insects, like honey-bees, put their store of honey away in their old cocoons. When the vessel is too small, they add to it at the opening a prolongation of wax. It may even occur that they build single cells, of an irregular globular form; this is a first step, the primitive wax-working. There is nothing very remarkable yet in this; but the next step becomes more important. Between this rude simplicity and the work, so finished, of the bee, we find something intermediate, the honey-cells of the domestic *mélipone*, of Mexico. The insect itself forms a transition, by its external marks, between the honey-bee and the humble-bee, and is nearer to the latter. To preserve its honey, it builds a pile of large spherical cells, all placed at equal distances apart, only that this distance is everywhere less than twice the radius of the spheres, so that they all encroach on each other, and are kept apart by a perfectly flat partition, having exactly the same thickness as the curved wall that bounds the free and spherical portion of each cell. If three are found to adjoin, the lines of separation cross at equal angles, and their common meeting-point rests on the top of a pyramid with three walls formed by the three cells, exactly as in a honeycomb. Reflecting on all this, Darwin says the thought occurred to him that, if the mélipone, which already builds its spheres at equal distances apart, were to come to disposing them symmetrically and back to back upon two opposite sides, there would result from this fact a construction as admirable as the bottom of a double rank of cells in the hive.

Has the constructive genius of the wasp and the bee passed through these transitions? It is impossible to assert it; but the evidence shows, and calculation confirms it, that some modifications, slight enough definitely, occurring in the instincts of the mélipone, might lead it, after an indefinite number of ages—we must always calculate on such periods of time—to build those three-angled pyramids which are already found in its constructions, in two or three ranks; then to build upon those pyramids, on each side, prolongations cylindrical in principle, like those which the humble-bee puts on its cocoons, and prism-shaped from their nearness to each other. Besides, such a construction upon a flat surface of its honey-cells by the mélipone would be nothing very extraordinary; in this way it builds the little chambers where it deposits its grubs.

In the general effort that produces the honey-comb, it is important to make allowance for that supreme law of necessity which Buffon refers to, and which compels each insect, if it makes a mistake in its measurements, to begin its work again, under penalty of seeing it destroyed by its neighbors. The bee's cell is no more an individual work than it is a work finished all at once. At the beginning, the six-sided plan is scarcely indicated; the original wall is clumsy, oftentimes too thick; it is attempted a second time, made thinner at the bottom, thickened at the top, crowded by force into its right place, and worked over and over constantly to the last perfection. The geometric regularity of the whole is the result of long tentative work. A multitude of bees are laboring on it at once, each for a time at one cell, then at another, and so on; twenty insects at least busy themselves with the first chamber, which at the outset is very irregular; new chambers are added, and the first remade. On all these points Darwin and other English naturalists have made very curious experiments, which deserve to be cited along with the observations of Francis Huber. He observed, to learn; they experimented, to explain. By dealing with swarms or individuals properly isolated, by modifying their conditions of labor, by deceiving their instinct, we should doubtless succeed in decomposing it by a kind of physiological analysis, at the same time that we should ascertain more clearly the tolerably large share that intelligence probably has in this industry of the bee. This is an aspect of the problem that is perhaps too much neglected by Darwin, but indicated by Mdlle. Clémence Royer in the notes added by her to the French translation of the "Origin of Species." We may ask, Why should not the bee itself be sensitive to that harmony of lines which strikes our eye in its work? Why deny so simple an impression as that which springs from regularity, to that brain which is of tiny dimensions, it is true, but which is quick to seize relations of far greater complexity between cause and effect, quick to choose the best place, to avoid an obstacle, to pursue with eye and sting the enemy of the hive? We have seen how the ant understands when an object is too large to pass through the entrance to its cave. The bee, to which we would attribute sensitiveness to regularity of lines, certainly has the notion of relations of length. There is a large moth, the death's-head sphinx, very fond of honey, and which asks nothing better than to make its way into the hive; its body, hairy and covered with horny plates, defies the sting. The bees, dreading this unwelcome visit, know very well how to protect themselves from it in regions where the sphinx abounds. As soon as the earliest ones begin to show themselves in the evenings of the longest days, as M. Blanchard relates, the bees narrow the opening of the hive in such a way that the robber can no longer get in. When the season for this moth has gone by, they destroy the new construction, and rebuild the passage of its original size. Certainly these are creatures

that have a measuring eye! Is there, then, so wide a distance between this power of eye and the sense of symmetry, which the lowest savage has who is sensitive to the harmony in the lines of a carving or a tattooing? Is it not simpler to suppose that the bee has something of the same sensibility, rather than a sort of mathematical instinct, such as is sometimes attributed to it? The whole cerebral physiology of insects remains to be created. While we are no further advanced, it is perhaps rash to allow much to their intellectual faculties, but it is certainly unreasonable to degrade them too much. And, besides, there is still in us that old sin of pride, on which Montaigne rallies us so delicately, just with respect to the reason of animals. He understood animals much better than Descartes; he loves them, he plays with his cat, and this intercourse enlightens him; he speaks with sound judgment of the too narrow share of intelligence allowed to animals by man, while he himself "goes soaring in imagination beyond the orbit of the moon."

As to the legionary ants, the connection of the successive phenomena serving to explain the appearance and development of their instinct was far more difficult to conceive. We might well have despaired of any reasonable deduction, had not certain facts, here and there in Nature, come to our aid and put us on the right track, by showing us elsewhere the same instinct, less developed, or modified in different ways. These observations, coördinated by Darwin, have been like flashes of light, and have allowed us to conceive the evolution of these singular habits in a manner at least plausible. Thus, it is not uncommon that certain ants, which do not usually take auxiliaries, carry away to their hills nymphæ that are found by chance in their neighborhood. It is not unlikely that some of these nymphæ may have happened to come out, and may have performed the functions of their special instinct in their adopted city. If, now, it is admitted that these services may be of some use to the hill, then it will thrive better, and afterward it may happen that the same chance captives and chance comings-out of nymphæ may be repeated. At last, the habit will be formed—then the instinct will supervene, of carrying off stolen nymphæ. At the same time the presence of these strangers will almost necessarily react upon the robber-ants. Their instincts and their organs will be simultaneously modified, always upon the same principle, in the direction most favorable to the special duty that they perform in the community. From step to step, by a succession of scarcely-perceptible modifications, accumulating through centuries and ages, we shall arrive at races of legionaries as dependent on their comrades' labors as the species studied by Peter Huber.

Each instinct that we study displays itself to us, in a manner, under an absolute form; we never see it change; therefore it is said to be unchangeable. This is the illusion common to all phenomena that are too slow for their progress to be measured by the life or the memory

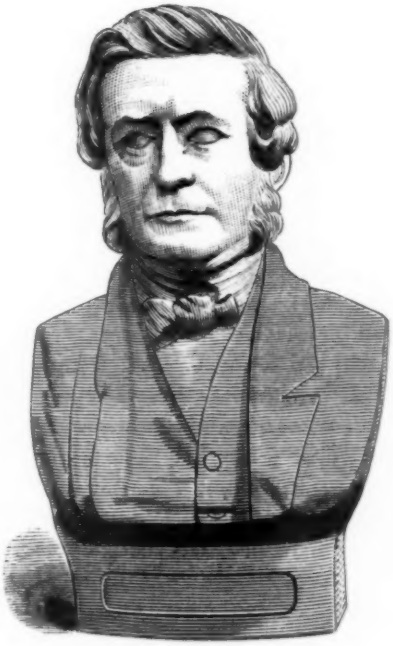
of man. Yet the European beaver and the oriole give us examples of instincts that go back to a date relatively not very ancient. We know now, too, that the nests of the same species of birds sometimes present remarkable enough variations in different countries. That Darwin should point out with great care these instincts, varying with latitudes, is very natural; but we should less naturally expect to find a similar fact, in the book of a partisan, of the unchangeableness of instincts. The leaf-cutter, another hymenopterous insect, lays its eggs in little chambers made of bits of leaves which it has rapidly cut. In our country it is always a rose-leaf. Yet, "we are assured," says M. Blanchard, "that our cutter of rose-leaves, finding itself in some place in Russia where there are no rose-bushes, makes its nest with willow or osier leaves." Therefore, instinct must vary in space as it has varied in time! It is not at all the case that the same legionaries are everywhere as dependent on their comrades as those that Peter Huber saw in the environs of Geneva. In England, as in Switzerland, the auxiliaries reared by the dark-red ants take complete care of the larvæ, while the legionaries alone go on expeditions; but in Switzerland the two castes together busy themselves about all works of construction or supply, while in England the legionaries alone go out to gather provisions and materials; the auxiliaries remain shut up within; they thus render less service to the community than they do in Switzerland.

It will be said, perhaps, that these differences are a very trifling matter. They are, at least, enough to show how the ancient doctrine of Cuvier has been shaken, and how, in the infinite lapse of time, those instincts may have become developed, which mere geographical accidents suffice to modify slightly. The grand solution of instinct is —Time; that immeasurable duration of those geological epochs which our mind holds in contemplation, but of which it can no more form an idea than of the measure of the heavenly spaces. Modern science begins to be amazed at those figures of ages which it must count since the rude attempts at primitive human industry. What shall we think of those times, measured by the planet's growth, through which the instinct of the legionary ants may have been originated, defined, and perfected? The ant not only saw the epoch of the reindeer and the mammoth, and the glaciers of the Jura creeping down the valley of the Rhone—it was a contemporary of that period which geologists mark by the lifting of the Alps. The ant is older on the earth than Mont Blanc. They existed already in the Jurassic period, very little different from what they are in our own times. While an inland sea still flowed over the site where later Paris was to stand, they were multitudinous in the central regions of Europe that were out of water. We may judge of this by the mass of their remains; they fill thick layers of territory at Oeningen, on the shores of Lake Constance, and at Radoboj, in Croatia; the rock is black with ants, all wonderfully preserved, with their claws and delicate antennæ. Entomologists now

count fifty species in Europe. More than a hundred have been found by Heer, of Zurich, and Mayr, of Vienna, in the cantons of Oeningen and Radoboj alone; several seem identical with existing species. Most of them have wings; these are males and females. Workers are rare; and that is explained by the nature of the rock, deposited at the bottom of still waters. The winged insects fell into it by thousands; the workers, more lowly in existence, attached to earth, have left fewer victims in the streams that preserve the record of that age. For the same reason, those sepulchres, so rich in species, teach us nothing of the habits or abodes of the ants of that time. What we do know is, that there were also plant-lice in the country, and that the larvæ of *phryganes* made for themselves even then, as they do now, those cases in which they live, and which they carry about everywhere with them. Some of these have been found at Oeningen. We have butterflies' wings of that era with their marks, if not with their coloring. Who knows whether we shall not some day discover a wasps'-nest dropped from a bough, and a trifle less regular than those of to-day? Even were it just as perfect, that would in nowise weaken the hypothesis of progressive development in the instinct by which it was built. Should we not have, beyond the Jurassic epoch, an enormous past, beside which the actual age now of the deposits of Oeningen and Radoboj is, perhaps, like a day or an hour in the history of man?

The grand result which the introduction of Darwin's ideas into biological science has had is, beyond question, to have transformed a subject hitherto deemed unapproachable and insolvable into a question of development that may be attacked by our investigations. Instinct, like the outward forms of animals, has always been made dependent on those first causes too high for man to raise his look to them. The observations of the English naturalist have brought the problem upon new ground; his logic, his science, have forced the world to accept at last the ideas formerly defended by Cuvier's opponents, by Lamarck and Geoffroy Saint-Hilaire. The doctrine of the immutability of animal forms has had its time, and that of the invariability of instinct is falling into ruin. Darwin proves, in fact, that it suffices to admit the principle of intelligence, which no one now denies to animals, and then the twofold influence of habit and hereditary tendency, and last that law, stated by himself, of absorption of the poorly-endowed races by those better endowed, to reach the conclusion that the finely-perfected instinct of the bee or the ant is nothing more than a purely natural phenomenon, a necessary consequence of life. The most complex instinct is merely an hereditary accumulation of very simple habits, of which the first source was always in the spontaneous intelligence of the individual. Instinct, then, including that of neuter animals, may be defined, "a group of habits, slowly acquired, and fixed by inheritance." Then it appears to us as independent, in some degree, of the forms of the animal; the variations it presents find their explanation;

it is contingent, it originates, it is modified, through circumstances, aided by time, and through ages helped by scarcely-perceptible accidents. In its turn, it insensibly leads the organs to become perfect in the direction conformed to the use made of them by the animal. Regarded in this way, connected in the last analysis with other first properties from which it results, instinct, instead of baffling investigation by the human mind, as they do, becomes a possible and proper object of research by experimental science. It is a new horizon opening before the physiologist for the discovery of the laws of life.—*Revue des Deux Mondes.*



PROFESSOR HENSLOW.

A SCIENTIFIC HOME MISSIONARY.[1]

JOHN STEPHENS HENSLOW is described as having been a beautiful boy with brown curling hair, a fine straight nose, a brilliant complexion, soft eyes, and a smile that reached everybody's

[1] The subject of the present sketch, who became an eminent clergyman, botanical professor, and scientific philanthropist, was born in Kent, England, in 1796. For the principal facts of the present article we are indebted to his biography by Rev. Leonard Jenyns, Henslow's brother-in-law, published by Van Voorst, of London, and we have made free use of his statements.—ED.

heart. He was active, observant, and intelligent, a favorite partner at childish parties, and danced elegantly. This beautiful boyhood unfolded into a noble manhood, which took a turn so original and instructive, that we cannot do better than give some account of it to the readers of the POPULAR SCIENCE MONTHLY.

Young Henslow early developed a taste for the study of natural objects, and for making collections and experiments. His scientific future was symbolized by an adventure made while yet a child in a frock, and which consisted in dragging all the way home from a field, a considerable distance off, an enormous fungus which was dried and long preserved in the family. The lad had good blood and a good chance; his grandfather, Sir John Henslow, Chief Surveyor of the Navy, was a man of scientific attainments and much ingenuity; his mother was an accomplished woman, fond of natural history, and an assiduous collector of natural and artificial curiosities. His father had a great taste for birds, kept an extensive aviary, and had an ample library of natural history. The drawing-master at his school was a good entomologist and introduced the boy to some of the eminent naturalists of the day, who gave direction to his studies. He collected insects in the woods of Kent, and crustacea and shells from the bed of the Medway. many of his specimens were new and valuable, and found their way into the drawers of the British Museum. At the age of eighteen he entered St. John's College, Cambridge, and four years later took his degree of B. A. A year subsequently, in 1819, he accompanied Prof. Sedgwick to the Isle of Wight, where he took his first practical lessons in geology. He had been elected Fellow of the Linnæan Society in 1818, became a Fellow of the Geological Society in 1819, and made his first essay in authorship by a contribution to its proceedings in 1821, when twenty-five years of age. Mr. Henslow had paid much attention to mathematics in college, was a thorough student of mineralogy and chemistry, and took a leading part in founding the Cambridge Philosophical Society, in 1819. In 1822 he was elected Professor of Mineralogy in the Cambridge University. He was not an eloquent lecturer, but he had a good voice, and a remarkably clear way of expressing himself. He cultivated the art of explanation and adapting his language to the capacity of his hearers, and thus became one of the very best lecturers of the day. But the chair of Mineralogy was not what Prof. Henslow wanted. His favorite study was botany, and, a vacancy occurring in this professorship, Prof. Henslow was elected to the position in 1823. This science, and natural history generally, were in a low state in the university at that time.[1] His predecessor

[1] "In a low state," the reader must remember, not merely from neglect, but from hostility on the part of the classicists and mathematicians who had possession of the establishment. Even years afterward, when, mainly under Prof. Henslow's influence, natural history studies began to receive attention, Edward Forbes spent a couple of days in Cambridge and wrote: "I was greatly pleased with my visit, except in one thing—to

had held the professorship for sixty-three years, and was a very old man. In fact, there had been no lectures on botany given in Cambridge for at least thirty years. Prof. Henslow took hold of the work with great zeal, improved the Botanical Gardens, rearranged and extended the Botanical Museum, and established one of the most perfect collections of plants to be anywhere found. He made his lectures extremely interesting by always having large numbers of specimens on hand which the students were required to study directly. He often took his class on botanizing excursions, which tended greatly to rouse their interest in the subject. Entomologists and mineralogists often accompanied them, and Prof. Henslow's extensive acquaintance with all branches of natural history, and the delight he took in imparting information to all who sought it, served to kindle an enthusiasm which aided very much to raise the position of science in the university.

Prof. Henslow married in 1823. His parents had always been desirous that he should go into the Church, and, as the salary from his professorship was less than a thousand dollars a year, and insufficient to support his family, he took orders and accepted a curacy which yielded him some additional income. His engaging manners and sympathetic disposition, combined with his intellectual accomplishments, gave him great influence over the students, which was felt not only in directing their tastes and pursuits, but in the formation of character. As soon as he became settled in Cambridge as a married man, he instituted the practice of receiving at his own house, one evening in the week, all who took the slightest interest in scientific, and especially natural history studies. At these gatherings all might learn something, and every one went away pleased. He would seek out any of the students that were reported to him as attached to natural history, and made converts to his favorite science of not a few who were thrown accidentally in his way. If any young man through timidity or reserve shrank from going to the professor's house, the open-hearted welcome which he received soon inspired confidence and put him at his ease. There are many now among the first naturalists of England who were then students at Cambridge, and who gratefully acknowledge the encouragement and assistance they received from Prof. Henslow, and bear testimony to his rare excellences, both of head and heart. Among these is the now world-renowned naturalist Mr. Charles Darwin, who furnished to Prof. Henslow's biographer the following reminiscences, which will interest the reader as well on account of the writer as of their subject. Mr. Darwin says:

find that natural history is discouraged as much as possible, and regarded as idle trifling by the thousand-and-one mathematicians of that venerated university." It was a life-long struggle of Prof. Henslow to raise natural history to a coördinate place with other subjects of university study, and it was but a short time before his death, in 1861, that he saw the triumph of his efforts. Degrees were then first granted to those who had obtained "honors" in natural history studies.

"I went to Cambridge early in the year 1828, and soon became acquainted, through some of my brother entomologists, with Prof. Henslow, for all who cared for any branch of natural history were equally encouraged by him. Nothing could be more simple, cordial, and unpretending, than the encouragement which he afforded to all young naturalists. I soon became intimate with him, for he had a remarkable power of making the young feel completely at ease with him; though we were all awe-struck with the amount of his knowledge. Before I saw him, I heard one young man sum up his attainments by simply saying that he knew every thing. When I reflect how immediately we felt at perfect ease with a man older and in every way so immensely our superior, I think it was as much owing to the transparent sincerity of his character, as to his kindness of heart; and, perhaps, even still more to a highly-remarkable absence in him of all self-consciousness. One perceived at once that he never thought of his own varied knowledge or clear intellect, but solely on the subject in hand. Another charm, which must have struck every one, was that his manner to old and distinguished persons and to the youngest student was exactly the same: to all he showed the same winning courtesy. He would receive with interest the most trifling observation in any branch of natural history; and, however absurd a blunder one might make, he pointed it out so clearly and kindly, that one left him no way disheartened, but only determined to be more accurate the next time. In short, no man could be better formed to win the entire confidence of the young, and to encourage them in their pursuits.

"His lectures on botany were universally popular, and as clear as daylight. So popular were they, that several of the older members of the university attended successive courses. Once every week he kept open house in the evening, and all who had cared for natural history attended these parties, which, by thus favoring intercommunication, did the same good in Cambridge, in a very pleasant manner, as the scientific societies do in London. At these parties many of the most distinguished members of the university occasionally attended; and, when only a few were present, I have listened to the great men of those days, conversing on all sorts of subjects, with the most varied and brilliant powers. This was no small advantage to some of the younger men, as it stimulated their mental activity and ambition. Two or three times in each session he took excursions with his botanical class; either a long walk to the habitat of some rare plant, or in a barge down the river to the fens, or in coaches to some more distant place, as to Gamlingay, to see the wild-lily of the valley, and to catch on the heath the rare natter-jack. These excursions have left a delightful impression on my mind. He was, on such occasions, in as good spirits as a boy, and laughed as heartily as a boy at the misadventures of those who chased the splendid swallow-tail butterflies across the broken and treacherous fens. He used to pause every now and then, and lecture on some plant or other object; and something he could tell us on every insect, shell, or fossil collected, for he had attended to every branch of natural history. After our day's work we used to dine at some inn or house, and most jovial we then were. I believe all who joined these excursions will agree with me that they have left an enduring impression of delight on our minds.

"As time passed on at Cambridge, I became very intimate with Prof. Henslow, and his kindness was unbounded. He continually asked me to his house, and allowed me to accompany him in his walks. He talked on all subjects, including his deep sense of religion, and was entirely open. I owe more than I can express to this excellent man. His kindness was steady. When Captain

Fitzroy offered to give up part of his own cabin to any naturalist who would join in the expedition in H. M. S. Beagle, Prof. Henslow recommended me as one who knew very little, but who, he thought, would work. I was strongly attached to natural history, and this attachment I owed, in large part, to him. During the five years' voyage, he regularly corresponded with me, and guided my efforts. He received, opened, and took care of all the specimens sent home in many large boxes; but I firmly believe that, during these five years, it never once crossed his mind that he was acting toward me with unusual and generous kindness.

"During the years when I associated so much with Prof. Henslow, I never once saw his temper even ruffled. He never took an ill-natured view of any one's character, though very far from blind to the foibles of others. It always struck me that his mind could not be even touched by any paltry feeling of vanity, envy, or jealousy. With all this equability of temper and remarkable benevolence, there was no insipidity of character. A man must have been blind not to have perceived that beneath this placid exterior there was a vigorous and determined will. When principle came into play, no power on earth could have turned him one hair's-breadth.

"After the year 1842, when I left London, I saw Prof. Henslow only at long intervals; but, to the last, he continued in all respects the same man. I think he cared somewhat less about science, and more for his parishioners. When speaking of his allotments, his parish children, and plans of amusing and instructing them, he would always kindle up with interest and enjoyment. I remember one trifling fact which seemed to me highly characteristic of the man: In one of the bad years for the potato, I asked him how his crop had fared, but, after a little talk, I perceived that, in fact, he knew nothing about his own potatoes, but seemed to know exactly what sort of crop there was in the garden of almost every poor man in his parish.

"In intellect, as far as I could judge, accurate powers of observation, sound sense, and cautious judgment, seemed predominant. Nothing seemed to give him so much enjoyment as drawing conclusions from minute observations. But his admirable memoir on the geology of Anglesea shows his capacity for extended observations and broad views. Reflecting over his character with gratitude and reverence, his moral attributes rise, as they should do in the highest character, in preëminence over his intellect. C. DARWIN."

The moral heroism, here testified to by Mr. Darwin, was an eminent trait of Prof. Henslow's character, and a key to his career; but there was one instance of it, in Cambridge, which may be mentioned in passing. In politics, Prof. Henslow was originally a Conservative or Tory. Lord Palmerston had long represented the university on the same side. But when the Duke of Wellington, who was at the head of the government, declared against reform in any shape whatever, there came a revolution which overthrew his administration, and Lord Palmerston went over to the Liberal side and joined the reformed ministry. Prof. Henslow, like many others, fell in with the movement, and, of course, made himself obnoxious to the charge of being a "turn-coat." He did not flinch from these attacks, and was at any moment ready to do his duty regardless of popular reprobation, and he soon had an opportunity of incurring it. In the borough election

of 1835, the "Tory agents" had notoriously resorted to bribery. The Liberals wanted to bring the offenders into court, but no one would incur the odium of "informing" against them. Under these circumstances Prof. Henslow readily offered himself as the nominal prosecutor. The storm of abuse and persecution that broke upon him for this is still well remembered in Cambridge. His biographer remarks: "Not only was the cry raised of 'Henslow, common informer!' whenever he appeared in the streets, but the same obnoxious words were placarded upon the walls in such large and enduring characters, that, even to this day (1861), more than a quarter of a century after the transaction, they are still distinctly legible in some places. They were seen, and smilingly pointed out to a friend, by the professor himself, within a year of his death, and I have, since his death, seen and read them myself. His services were, however, deeply appreciated at the time, for he received three handsome testimonials: one from the town of Cambridge; another from the town committee for the suppression of corruption; and the third from a committee of noblemen and gentlemen." The rule that Prof. Henslow laid down for the guidance of conduct in such circumstances, and which he rigorously conformed to himself, was expressed in the following noble words: "I would have every Tory consistent, and every Radical consistent, and every Whig consistent, until either of them shall have become convinced that he has been in error, and then I would have him change his politics, regardless of every risk, and despising the shame which the world will heap upon him. But what I would have every man strive to possess is 'moral courage,' sufficient to declare his own opinions unhesitatingly in the face of the world, and adequate to maintain them unflinchingly against all influence whatever."

The position of Prof. Henslow at Cambridge was every thing that would satisfy the usual ambition of a man of science. He was profoundly appreciated in the institution, he was beloved by the students, and he had given a new life to the class of studies to which he was devoted. Yet all this did not satisfy him, and he seized the first opportunity to leave Cambridge, and enter a field of labor of a very different kind, and for which, as the result proved, he was remarkably endowed. As his talents and high character became known, the Government sought his influence for some of the responsible trusts in its gift, and it was in contemplation to offer him the See of Norwich. It is a terrible temptation in England to get the place of bishop, and while many sigh, labor, and intrigue for it, those who decline it when offered are exceedingly few. Prof. Henslow, when he heard of the danger, fled to his chamber, and prayed fervently to be delivered from the temptation. His prayers were answered, and, instead of the bishopric, he received the crown living of the parish of Hitcham, with an income of a thousand pounds a year. The place is in Suffolk, not far from Cambridge, and he entered upon the charge of it in 1837. His

first intention was to continue his relation with the university, and divide his work between Cambridge and Hitcham; but, finding that the duties of the latter place did not permit his absence, he took up his residence there in 1839. How different was the sphere of exertion upon which he had now entered will be apparent when we glance at the condition of the inhabitants of the parish when he first went among them.

The village of Hitcham consisted of one long, straggling street, and the parish contained rather more than a thousand persons, scattered over some 4,000 acres of land. The property of the parish was assessed at $30,000 a year, yet there was only a dame-school in the place. The unemployed and vagabond laborers were so numerous that the poor-rate in 1834 amounted to $5,000—equal, it was said, to over $6 for each man, woman, and child, in the village. The people were sunk to almost the lowest depths of moral and physical debasement. Ignorance, crime, and vice were rife, and the worst characters were addicted to poaching, sheep-stealing, drunkenness, and all kinds of immorality. The less vicious were more fond of idleness than work, and lolled about the road-sides, dead to all sense of moral shame, so long as they could live at the parish expense. Parish relief or charity was not unfrequently levied by bands of forty or fifty able-bodied laborers who had been in the habit of intimidating the previous rector into instant compliance with their demands. The houses of the poor were described as having been many of them little better than hovels, in which the common decencies of life could hardly be carried out. The church was almost empty on Sunday, and but little respect was paid to its ordinances. The previous rector had been satisfied with discharging his usual Sunday duties, and left the people to themselves during the week.

Such was the field which Prof. Henslow left Cambridge to cultivate. He went there as a missionary, to reclaim it from inveterate heathenism, which still passed under a Christian name. His difficulties were of the most formidable kind, and he had to grapple with them single-handed, for there were no influential persons in the parish either to coöperate in his work, or to encourage him in pursuing it. The parties with whom he had to deal were the farmers who rented the land from the landlords, and the laborers whom the farmers employed. The farmers are represented as having been intellectually raised but little above their laborers, as ignorant, obstinate, and prejudiced, and they doggedly opposed the new rector in all his schemes, and threw every possible obstacle in his way. But he was not a man to flinch from what he had undertaken, and, coolly estimating the difficulties of the situation, he set himself to work to reclaim his flock from their degradation, to industry, sobriety, independence, and self-respect. It was obvious enough that the inculcation of moral and religious lessons would have been utterly lost upon them—would have been like throwing pearls before swine—because men must be civilized before they

can be effectually Christianized. Prof. Henslow therefore commenced by gaining the confidence of those whom he wished to influence, and to do this he had to adapt himself to them, and utilize whatever forces he could find available. He began by amusing them. He got up a cricket club, and encouraged various manly games. He introduced ploughing-matches, and competitive exhibitions. His acquaintance with chemistry enabled him to construct fireworks, which he would let off upon the rectory lawn, and which were a great attraction to the people. He brought out various natural and artificial curiosities, which were at first vacantly stared at, but, with his extraordinary faculty of adapting his language and illustrations to the commonest capacity, he gradually kindled an interest in the minds of many which grew into a desire to learn. Other recreations and incitements followed, which will be presently referred to. Prof. Henslow resorted to many measures of amelioration and improvement, and carried them all along together; but, in our brief sketch of his labors, we must consider them separately; and we will take up first what he did for the laborers, next for the farmers, and lastly, what he accomplished for the education of the children:

One of the first evils which he attacked was the degradation and dependence of the laborers. The Hitcham farmers held their men in brutal subjection, viewing them as little better than slaves, for whose concern they felt no interest. They were, therefore, the enemies of every measure for the improvement of the laboring-class. Prof. Henslow considered the lack of an independent home as one of the great barriers to the elevation of the working-men, and he therefore urged the adoption of the "allotment system," by which the laborers might become the owners or tenants of small pieces of ground, to be cultivated by themselves for their own benefit. This encountered the fiercest opposition from the farmers, and led to a long and determined struggle. All sorts of objections were raised. It was said the laborers would steal the farmers' seed to sow their own ground; they would give their masters slack work in order to reserve their strength for their own patches at the end of the day. But the worst difficulty was the profound class or caste spirit which pervades English society, and which impelled the farmers to fight the change, because it would raise the laborer, and bring him one step nearer to themselves. It was in 1845 that Prof. Henslow made his first public appeal upon this subject, in which he pointed out the many advantages that would result from the allotment system to the laboring-class. He urged the reform energetically, and initiated it by granting portions of his own land for the purpose. He pushed the project until he had got fifty more of one-quarter of an acre each. The farmers here made a stand, and determined to crush the whole system. They went into coöperation, and gave mutual pledges that they would "refuse all employment and show no favor to any day-laborer who should hold an allotment."

The storm raged about the rector, who persevered without losing either his patience or his temper. He denounced the selfish action of the farmers, and gave them to understand that he would submit to no dictation, and was determined to carry out his intentions. Fortunately, his salary and position did not depend upon them, as they would quickly have dismissed him; but, finding that the rector's purpose was not to be shaken, their opposition at length abated. The measure was extended, and the most salutary consequences followed in the general conduct of the people. Many instances were known in which "an allotment has been the means of reclaiming the criminal, reforming the dissolute, and of changing the whole moral character and conduct." At the time of Prof. Henslow's death the allotments in his parish amounted to nearly 150 in number, and their advantages were no longer denied.

Nor did Prof. Henslow encounter much less difficulty in his efforts to improve the condition of the farmers themselves. A good chemist, botanist, and geologist, and a close student of scientific agriculture, he was prepared to help the agriculturists with applied and available knowledge, yet they strenuously resisted his efforts to teach them. But he was not to be baffled in his exertions. He took up the practical subject of the economy of fertilizers, in a series of popular letters to a country newspaper, and treated it with such familiarity and skill as to arrest the attention of the farmers. He spoke to them in the farmers' club upon the same subject, and the address, together with the letters, was printed and widely distributed. Having at length aroused their attention, he pressed them into the work of testing the proposed views, by observations and experiments of their own. The relative value of different kinds of organic and inorganic manures, their adaptation to special crops, how they should be applied, and the extent to which manure-heaps should be allowed to ferment and decompose, were open questions, and he showed the farmers that they were the parties to settle them. Liebig had suggested the addition of gypsum to the manure-heap, to fix the ammonia, and Henslow suggested that the farmers of Suffolk should try the experiment; and, to get as many enlisted as possible, he circulated printed forms to be filled up by the experimenters with the results to which they might arrive. But few at first responded to the call, and all kinds of objections were urged; but at length 69 farmers sent in applications for the printed forms, and consented to undertake the experiments. The result of these efforts was the stirring up of the farmers to a more methodical and scientific way of conducting their agricultural operations. Prof. Henslow did not expect to make them philosophers, but to make them think, and to do something toward converting the art of husbandry into the science of agriculture; and he received many communications which showed that his letters and lectures had exerted a wide and wholesome influence.

It was in connection with these efforts to aid the farmers that Prof. Henslow made the memorable discovery of the agricultural value of the so-called coprolites, or phosphatic nodules, found in the red crag at Felixstowe, in Suffolk. They were shown to contain 56 per cent. of phosphate of lime, and therefore to be capable of replacing bones in fertilization. He called attention to the similar concretions abundantly distributed in the upper greensand of Cambridgeshire, which were even richer in phosphate, and which have since yielded immense profits both to the proprietors of the pits and the farmers who used the product.

Prof. Henslow had paid much attention to entomology; and his knowledge of plants, and the parasitic insects which infest them and destroy the crops, enabled him to instruct the farmers upon this subject. He closely investigated the diseases of wheat, potatoes, and clover, and diffused the results of his inquiries in lectures, tracts, and newspaper correspondence.

As he lived in an agricultural community, in which all were interested in farm products and processes, Prof. Henslow resorted to other means of quickening the general interest in these matters, and of enlisting the sympathy of laborers as well as farmers. For this purpose he instituted horticultural shows, at which there was a distribution of prizes for such products as wheat, fruit, flowers, vegetables, and honey, and sometimes for works of mechanical ingenuity calculated to encourage the laborers to spend their long winter evenings profitably. There were two of these shows in each season, in July and September. They began in 1850, and were kept up until the time of his death. Tents were pitched for receiving the productions of the cottagers' gardens, and the allotment-tenants received premiums for the best management of their pieces of ground. Besides the tents for the more special purposes of the show, there was always one assigned to a miscellaneous collection of specimens in natural history—animals, birds, reptiles, insects' nests, etc., with various specimens from the domestic arts and antiquities. This the professor called his "Marquee Museum." On one occasion the dimensions of the trunk of the great mammoth tree (*Wellingtonia*) were traced out on the lawn with a diagram, showing its size in comparison with other trees. There was much to gratify the eye; but sight-seeing is always wearisome, and Prof. Henslow alleviated the routine of the day, and gave an intellectual turn to the proceedings, by summoning as many of the company as chose to come to the museum, and delivering to them little lectures, or "lecturets," as he termed them. He would talk to the women about textile fabrics or domestic operations, and to the different groups on processes of manufacture, or local specimens of natural history, or the diseases of vegetation. Nor were amusements neglected; swings and poles were set up for gymnastic exercises, and foot-ball and other games were encouraged on the grounds. The scene was

one of entertainment and instruction, and promotive of good feeling on the part of all who participated in it. The influence of these exhibitions was so beneficial, and became so well known, that large numbers flocked to them from a distance, and similar shows were got up in other places.

One of the schemes devised by Prof. Henslow for alleviating the hard, monotonous life of the laboring population, and combining recreation with improvement, was the arrangement of excursions to neighboring places of interest. Knowing that those who always stay at home are apt to become narrow and prejudiced, he sought to afford them the opportunity of observing the ways and habits of other places, and to open to them not merely agreeable sights, but sources of knowledge from which they had been previously shut out. From one to two hundred persons usually accompanied him, and his preparations for these excursions were always very methodical; for he aimed to combine moral discipline with healthful amusement. A "recreation fund" was raised, and the poor always contributed something toward the expenses. Tickets were issued, limiting the number of those attending, and printed circulars were sometimes prepared with plans of the route, regulations for the party, and often copious notes concerning the place and objects to be visited. An eleven-page pocket-guide was got up on one occasion for the use of the visitors at Cambridge, giving an account of the colleges, museums, and libraries of the university. Sometimes they went to the neighboring towns, to manufacturing places, or to the sea-shore. But the professor was always ready with his interesting "lecturets" to explain every thing to his flock of eager listeners. The impression left by these holiday excursions upon the minds and hearts of the simple laborers was most gratifying, and, as one of them remarked to Prof. Henslow, "Our heads would not be so full of drink if we had such things to occupy our minds."

The task which Prof. Henslow had undertaken was one of immediate and practical social amelioration, and this compelled him to grapple with the adult ignorance and the indurated prejudices of the community. But he did not forget the children. When he went to Hitcham, there was but a single, very poor school in the parish, but he lost no time in establishing a better one. Meeting with but little support from his parishioners, he had to bear the greater part of the expense himself in the erection of a school-house and the payment of a teacher. He had to deal with the children of an ignorant and stolid peasantry, yet he brought his scientific resources to bear upon them with such success that his humble parish-school acquired a national reputation, was visited by people from all parts of the country, and was inquired into by Parliament when settling the policy of its public schools.

Prof. Henslow struck boldly out from the traditional method, and did a thing unheard of in England, which was, to introduce his favorite

science of botany into a school for the children of the lowest classes. Prof. Henslow's object was to break in upon the slavish and stupefying routine of the schoolroom, and to substitute, for the endless drudgery of mere lesson-learning from books, the exercise of the childish faculties upon Nature itself. His object was to awaken the mind to spontaneous action, to open the observant faculties, and expand the reasoning powers, rather than to impart second-hand knowledge, and to load the memory with the contents of books. And this he succeeded in doing. He introduced a study which excited their interest, and "furnished them with innocent and rational amusement in those leisure hours which so many servants and poor idly throw away when their required work is done;" which "tends to raise their thoughts to the contemplation of the Creator, and to make them mindful as well as observant of that infinite wisdom and goodness of which they see everywhere around them such abundant proofs," and which, moreover, taught them the use of their minds in inquiring, comparing, judging, and thinking for themselves.

It is to be observed that Prof. Henslow did not, by any means, undertake to establish a botanical school; in fact, but a very small portion of the time was given to the subject. His habit was to attend the school regularly every Monday afternoon, for the purpose of giving a lesson in botany from an hour and a half to two hours in length, the main work of the pupils being by themselves and out of school. The pupils varied in age from eight to eighteen, and the class was limited to 42 in number. Into the details of his teaching we have no space here to enter. The whole essence and value of it consisted in the regular and constant study of plants themselves. The pupils ranged the woods and fields of Hitcham for specimens, and their work consisted in dissecting, analyzing, and classifying them. The class was graded; the older pupils became teachers, and the younger were promoted as they became proficient in their work. The children made herbariums of dried plants, and one pupil-teacher "actually collected in rural strolls, and afterward dried and correctly named, more than 250 specimens of plants." The children brought their botanical acquirements to bear to enrich the horticultural show, to which reference has been made. They brought their dried collections and fresh, wild-flower nosegays, and competed for the prizes offered for the largest collections, the most tasteful arrangements, and the most accurate descriptions. In 1858, at the July show, 50 children competed for the "wild-flower nosegay," and 26 received prizes.

It is almost superfluous to say that this invaluable experiment in education was not an example of "compulsory education." Compulsion implies resistance; a resort to brute force, when higher forces fail, or are not tried. But the coercive system forces the question upon us, Is anybody fit to teach who cannot wield the higher agencies of control? Should not the very first qualification of a teacher of the young

be a love of children? This, at all events, was a prime qualification of Prof. Henslow. His biographer says: "He had a playful way with children, which won their affections, as well as their attention to what he was teaching them, and which was one secret of their success. He would always speak kindly to them, and encourage them in their different little ways. All who competed for the wild-flower nosegay prizes, though they did not succeed in getting a prize, were allowed a pinch of 'white snuff,' as he jokingly called it, or sugar-plums. He generally had a snuffbox full of these sugar-plums in his pocket when he went into the village, offering a pinch to any of the little children whom he happened to meet." Of course, his botanical pupils were all volunteers. They entered with spirit into their work, took it home with them, pursued it in their rambles, recurred to it in hours of play, compared notes among themselves, and needed no "compulsion." How eager was their delight, was shown by their grief whenever the lessons were interrupted. In a public address, Prof. Henslow said: "No one who had heard the lamentations uttered upon my announcing, at our last lesson before Easter, the necessity of six weeks' absence at Cambridge duties, could possibly have doubted the great interest the children took in these exercises."

As to the educational value of this teaching, although it occupied but a small fraction of regular school-time, it was of the highest importance. It was not merely that the children got a knowledge of botany, but that they mastered its rudiments in such a way as to gain the most important intellectual benefits. There is plenty of unmistakable evidence upon this point; we have space only for an extract from the cautious statement of one of her Majesty's inspectors of schools, who says: "That the botanical lessons, as handled by the professor in his own national school, did draw largely upon the intelligent powers of his little pupils' minds, there can be no question. The simple system to which he had reduced his plan of making the children break up the various specimens into their component parts, arrange those parts, observe their characters and relations to each other, and thence *arrive at conclusions for themselves*, was very far from being the mechanical process which many, before witnessing it, might have supposed 'botany in the national schools' to represent. And I think it is not at all unfair to say that these children, who, out of school, were (as I had many opportunities of judging) much more conversable than the generality of children in rural parishes, owed a considerable share of the general development of their minds to the botanical lessons and the self-exercise connected with them."

Prof. Henslow's method of teaching botany to the young was one of his great successes, and is a permanent contribution to education. He commenced a little book embodying the plan, but did not live to finish it; and he got along with printed lists, forms, and schedules, all being directed by his lectures and by his constant supervision of

the plant-studies of his pupils. The fame of his success went abroad, and he was solicited to lecture in many places, and to assist in organizing the botanical work in various schools and colleges. Like Faraday, he was invited by Prince Albert to lecture to the royal children, whom he interested in the same way that he had done the pupils of his Hitcham classes.

Other points of great interest in Prof. Henslow's career and character we should be glad to dwell upon, but our sketch is already overdone. Sufficient, however, has been said to show how science may increase the usefulness of a clergyman, and prepare the way for his higher work—and that higher work was not neglected by Prof. Henslow. He not only labored hard and perseveringly for the temporal good of his parishioners, but he discharged toward them with fidelity the duties of a Christian minister. In the twenty-four years of his residence at Hitcham there was a period of twelve years when he was not absent from the parish on a single Sunday. The secret of so much varied work was a strong constitution, unremitting industry, and strict method in the disposal of his time. But the strongest constitutions have their limits, and a false security tends to their being often overpassed. Prof. Henslow was under a constant strain, and the illness that terminated his life was probably brought on by his "incessant mental and manual labor." He passed away May 14, 1861, and his loss was deeply felt in the world of science, in his university, and in the parish to which he had devoted so much of his unselfish life.

THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

XI.—*The Political Bias.*

EVERY day brings events which, showing the politician what the events of the next day are likely to be, serve also as materials for the student of Social Science. Passing occurrences may have their special meanings sought, as by the many, or may have their general meanings sought, as by the few. Scarcely a journal can be read, that does not supply a fact which, beyond the proximate implication seized by the party-tactician, has an ultimate implication of value to the sociologist. Thus *à propos* of political bias, I am, while writing, furnished by an Irish paper with an extreme instance. Speaking of the late Ministerial defeat, the *Nation* says:

"Mr. Gladstone and his administration are hurled from power, and the iniquitous attempt to sow broadcast the seed of irreligion and infidelity in Ireland has recoiled with the impact of a thunder-bolt upon its authors. The men who

so long beguiled the ear of Ireland with specious promises, who mocked us with sham reforms and insulted us with barren concessions, who traded on the grievances of this country only to aggravate them, and who, with smooth professions on their lips, trampled out the last traces of liberty in the land, are to-day a beaten and outcast party."

Which exhibition of feeling we may either consider specially, as showing how the "Nationalists" are likely to behave in the immediate future; or may consider more generally, as giving us a trait of Irish nature tending to justify Mr. Froude's harsh verdict on Irish conduct in the past; or may consider most generally, after the manner here appropriate, as a striking example of the distortions which the political bias works in men's judgments.

When we remember that all are thus affected more or less, in estimating political antagonists, their acts and their views, we are reminded what an immense obstacle political partisanship is in the way of Social Science. I do not mean simply that, as all know, it often determines opinions about pending questions; as shown by cases in which a measure, reprobated by Conservatives when brought forward by Liberals, is approved when brought forward by their own party. I refer to the far wider effect it has on men's interpretations of the past and of the future; and therefore on their sociological conceptions in general. The political sympathies and antipathies fostered by the conflicts of parties, respectively upholding this or that kind of institution, become sympathies and antipathies drawn out toward the allied institutions of other nations, extinct or surviving. These sympathies and antipathies inevitably cause tendencies to accept or reject favorable or unfavorable evidence respecting such institutions. The well-known contrast between the pictures which the Tory Mitford and the Radical Grote have given of the Athenian democracy, serves as an instance to which many parallels may be found. In proof of the perverting effects of the political bias, I cannot do better than quote some sentences from Mr. Froude's lecture on "The Scientific Method applied to History:"

"Thucydides wrote to expose the vices of democracy; Tacitus, the historian of the Cæsars, to exhibit the hatefulness of imperialism."[1]

"Read Macaulay on the condition of the English poor before the last century or two, and you wonder how they lived at all. Read Cobbett, and I may even say Hallam, and you wonder how they endure the contrast between their past prosperity and their present misery."[2]

"An Irish Catholic prelate once told me that to his certain knowledge two millions of men, women, and children had died in the great famine of 1846. I asked him if he was not including those who had emigrated. He repeated that over and above the emigration two millions had actually died; and added, 'we might assert that every one of these deaths lay at the door of the English Government.' I mentioned this to a distinguished lawyer in Dublin, a Protestant.

[1] Froude, "Short Studies on Great Subjects," Second Series, 1871, p. 480.
[2] Ibid., p. 483.

His gray eyes lighted up. He replied: 'Did he say two millions now—did he? Why, there were not a thousand died—there were not five hundred.' The true number, so far as can be gathered from a comparison of the census of 1841 with the census of 1851, from the emigration returns, which were carefully made, and from an allowance for the natural rate of increase, was about two hundred thousand."[1]

Further insistance on this point is needless. That the verdicts which will be given by different party journals upon each ministerial act may be predicted, and that the opposite opinions uttered by speakers and applauded by meetings concerning the same measure may be foreseen if the political bias is known, are facts from which any one may infer that the party politician must have his feelings greatly moderated before he can interpret, with even approximate truth, the events of the past, and draw correct inferences respecting the future.

Here, instead of dilating upon this truth, I propose to draw attention to kindred truths that are less conspicuous. Beyond those kinds of political bias indicated by the names of political parties, there are certain kinds of political bias transcending party limits. Already in the chapter on "Subjective Difficulties—Emotional," I have commented upon the feeling which originates them—the feeling drawn out toward the governing agency. In addition to what was there said about the general effects of this feeling on sociological speculation, something must be said about its special effects. And first, let us contemplate a common fallacy in men's opinions about human affairs, which pervades the several fallacies fostered by the political bias.

Results are proportionate to appliances—see here the tacit assumption underlying many errors in the conduct of life, private and public. In private life every one discovers the untruth of this assumption, and yet continues to act as though he had not discovered its untruth. Reconsider a moment, under this fresh aspect, a familiar experience lately dwelt upon.

"How happy I shall be," thinks the child, "when I am as old as my big brother, and own all the many things he will not let me have!" "How happy," the big brother thinks, "shall I be when, like my father, I have got a house of my own and can do as I like!" "How happy I shall be," thinks the father, "when, achieving the success in prospect, I have got a large income, a country-house, carriages, horses, and a higher social position!" And yet at each stage the possession of the much-desired aids to satisfaction does not bring all the happiness expected, and brings many annoyances.

A good example of the fallacy, that results are proportionate to appliances, is furnished by domestic service. It is an inference naturally drawn that, if one servant does so much, two servants will do twice as much; and so on. But when this common-sense theory is tested by

[1] Froude, "Short Studies on Great Subjects," Second Series, 1871, pp. 483, 484.

practice, the results are quite at variance with it. Not simply does the amount of service performed fail to increase in proportion to the number of servants, but frequently it decreases: fewer servants do more work and do it better.

Take, again, the relation of books to knowledge. The natural assumption is, that one who has stores of information at hand will become well informed. And yet, very generally, when a man begins to accumulate books he ceases to make much use of them. The filling of his shelves with volumes, and the filling of his brain with facts, are processes apt to go on with inverse rapidities. It is a trite remark that those who have become distinguished for their learning have often been those who had great difficulties in getting books. Here, too, the results are quite out of proportion to the appliances.

Similarly, if we go a step further in the same direction—not thinking of books as aids to information, but thinking of information as an aid to guidance. Do we find that the quantity of acquirement measures the quantity of insight? Is the amount of cardinal truth reached to be inferred from the mass of collected facts that serve as appliances for reaching it? By no means. Wisdom and information do not vary together. Though there must be data before there can be generalization, yet ungeneralized data, accumulated in excess, are impediments to generalization. When a man's knowledge is not in order, the more of it he has the greater will be his confusion of thought. When facts are not organized into faculty, the greater the mass of them the more will the mind stagger along under its burden, hampered instead of helped by its acquisitions. A student may become a very Daniel Lambert of learning, and remain utterly useless to himself and all others. Neither in this case, then, are results proportionate to appliances.

It is so, too, with discipline, and with the agencies established for discipline. Take, as an instance, the use of language. From his early days, the boy whose father can afford to give him the fashionable education, is drilled in grammar, practised in parsing, tested in detecting errors of speech. After his public-school career, during which words, their meanings, and their right applications, almost exclusively occupy him, he passes through a university where a large, and often the larger, part of his attention is still given to literary culture—models of style in prose and poetry being daily before him. So much for the preparation; now for the performance. It is notorious that commentators on the classics are among the most slovenly writers of English. Readers of *Punch* will remember how, years ago, the Provost and Head-master of Eton were made to furnish food for laughter by quotations from a letter they had published. Recently the Head-master of Winchester has given us, in entire unconsciousness of its gross defects, a sample of the English which long study of language produces. If from these teachers, who are literally the select of the select, we turn to men otherwise selected, mostly out of the same highly-disciplined class—

men who are distilled into the House of Commons, and then redistilled into the Ministry, we are again disappointed. Just as, in the last generation, royal speeches, drawn up by those so laboriously trained in the right uses of words, furnished for an English grammar examples of blunders to be avoided; so, in the present generation, a work on style might fitly take, from these documents which our government annually lays before all the world, warning instances of confusions, and illogicalities, and pleonasms. And then on looking at the performances of men not thus elaborately prepared, we are still more struck by the seeming anomaly. How great the anomaly is, we may best see by supposing some of our undisciplined authors to use expressions like those used by the disciplined. Imagine the self-made Cobbett deliberately saying, as is said in the last royal speech, that—

"I have kept in *view* the double *object* of an equitable *regard* to existing circumstances, and of securing a general provision more permanent in its character, and resting on *a reciprocal and equal basis*, for the commercial and maritime transactions of the two countries."[1]

Imagine the poet, who had "little Latin and less Greek," directing that—

"No such address shall be delivered in any place where the assemblage of persons to hear the same *may cause obstruction to the use of* any road or walk by the public."[2]

—a passage which occurs, along with half a dozen laxities and superfluities, in the eighteen lines announcing the ministerial retreat from the Hyde Park contest. Imagine the ploughman Burns, like one of our scholars who has been chosen to direct the education of gentlemen's sons, expressing himself in print thus:

"I should not have troubled you with this detail (which was, indeed, needless in my former letter) if it was not that I may appear to have laid a stress upon the dates which the boy's accident had prevented me from being able to claim to do."[3]

Imagine Bunyan the tinker publishing such a sentence as this, written by one of our bishops:

"If the 546 gentlemen who signed the protest on the subject of deaconesses had thought proper to object to my having formally licensed a deaconess in the parish of Dilton's Marsh, or to what they speak of when they say that 'recognition had been made' (I presume on a report of which no part or portion was adopted by resolution of the Synod) 'as to sisters living together in a more conventual manner and under stricter rule,' I should not have thought it necessary to do more than receive with silent respect the expression of their opinion," etc., etc.[4]

Or, to cite for comparison modern self-educated writers, imagine such a sentence coming from Alexander Smith, or Gerald Massey, or the

[1] Daily papers, February 7, 1873.
[2] *Times* and *Post*, February 11, 1873.
[3] *Times*, November 25, 1872.
[4] *Times*, November 27, 1872.

"Norwich Weaver-boy" (W. J. Fox), or the "Journeyman Engineer." Shall we then say that, in the case of literary culture, results are proportionate to appliances? or shall we not rather say that, as in other cases, the relation is by no means so simple a one.

Nowhere, then, do we find verified this assumption which we are so prone to make. Quantity of effect does not vary as quantity of means. From a mechanical apparatus up to an educational system or a social institution, the same truth holds. Take a rustic to see a new machine, and his admiration of it will be in proportion to the multiplicity of its parts. Listen to the criticism of a skilled engineer, and you will find that from all this complication he infers probable failure. Not elaboration but simplification is his aim; knowing, as he does, that every additional wheel and lever implies inertia and friction to be overcome, and occasional derangement to be rectified. It is thus everywhere. Up to a certain point, appliances are needful for results; but, beyond that point, results decrease as appliances increase.

This undue belief in appliances, joined with the general bias citizens inevitably have in favor of governmental agencies, prompts the multiplication of laws. It fosters the notion that a society will be the better the more its actions are everywhere regulated by artificial instrumentalities. And the effect produced on sociological speculation is, that the benefits achieved by laws are exaggerated, while the evils they entail are overlooked.

Brought to bear on so immensely complicated an aggregate as a society, a law rarely, if ever, produces as much direct effect as was expected, and invariably produces indirect effects, many in their kinds and great in their sum, that were not expected. It is so even with fundamental changes: witness the two we have seen in the constitution of our House of Commons. Both advocates and opponents of the first Reform Bill anticipated that the middle classes would select as representatives many of their own body. But both were wrong. The class-quality of the House of Commons remained very much what it was before. While, however, the immediate and special results looked for did not appear, there were vast, remote, and general results foreseen by no one. So, too, with the recent change. We had eloquently-uttered warnings that delegates from the working-classes would swamp the House of Commons; and nearly every one expected that, at any rate, a sprinkling of working-class members would be chosen. Again all were wrong. The conspicuous alteration looked for has not occurred; but, nevertheless, governmental actions have already been much modified by the raised sense of responsibility. It is thus always. No prophecy is safer than that the results anticipated from a law will be greatly exceeded in amount by results not anticipated. Even simple physical actions might suggest to us this conclusion. Let us contemplate one.

You see that this wrought-iron plate is not quite flat: it sticks up a little here toward the left—"cockles," as we say. How shall we flatten it? Obviously, you reply, by hitting down on the part that is prominent. Well, here is a hammer, and I give it a blow as you advise. Harder, you say. Still no effect. Another stroke? Well, there is one, and another, and another. The prominence remains, you see—the evil is as great as ever. But this is not all. Look at the warp which the plate has got near the opposite edge: where it was flat before it is now curved. A pretty bungle we have made of it. Instead of curing the original defect, we have produced a second. Had we asked an artisan practised in "planishing," as it is called, he would have told us no good was to be done, but only mischief, by hitting down on the projecting part. He would have taught us how to give variously-directed and specially-adjusted blows with a hammer elsewhere: so attacking the evil not by direct but by indirect actions. The required process is less simple than you thought. Even a sheet of metal is not to be successfully dealt with after those common-sense methods in which you have so much confidence. What, then, shall we say about a society? "Do you think I am easier to be played on than a pipe?" asks Hamlet. Is humanity more readily straightened than an iron plate?

Many, I doubt not, failing to recognize the truth that, in proportion as an aggregate is complex, the effects wrought by an incident force become more multitudinous, complicated, and incalculable, and that, therefore, a society is, of all kinds of aggregates, the kind most difficult to affect in an intended way and not in unintended ways—many such will ask evidence of the difficulty. Response would perhaps be easier were the evidence less abundant. It is so familiar as seemingly to have lost its significance; just as perpetually-repeated salutations and prayers have done. The preamble to nearly every act of Parliament supplies it; in the report of every commission it is presented in various forms; and, for any one asking instances, the direction might be—Hansard *passim*. Here I will give but a single example which might teach certain rash enthusiasts of our day, were they teachable. I refer to measures for the suppression of drunkenness.

Not to dwell on the results of the Maine Law, which, as I know from one who lately gave me his personal experience, prevents the obtainment of stimulants by travellers in urgent need of them, but does not prevent secret drinking by residents—not to dwell, either, upon the rigorous measures taken in Scotland in 1617, "for the restraint of the vile and detestable vice of drunkenness daily increasing," but which evidently did not produce the hoped-for effect—I will limit myself to the case of the Licensing Act, 9 George II., chapter 23, for the arresting the sale of spirituous liquors (chiefly gin) by prohibitory licenses:

"Within a few months after it passed, Tindal tells us, the commissioners of excise themselves became sensible of the impossibility or unadvisableness of carrying it rigorously into execution. . . . Smollett, who has drawn so dark a picture of the state of things the act was designed to put down, has painted in colors equally strong the mischiefs which it produced: 'The populace,' he writes, 'soon broke through all restraint. Though no license was obtained, and no duty paid, the liquor continued to be sold in all corners of the streets; informers were intimidated by the threats of the people; and the justices of the peace, either from indolence or corruption, neglected to put the law in execution.' In fact, in course of time, 'it appeared,' he adds, 'that the consumption of gin had considerably increased every year since those heavy duties were imposed.'"[1]

When in 1743 this Act was repealed, it was shown during the debates that—

"The quantity of gin distilled in England, which in 1684, when the business was introduced into this country, had been 527,000 gallons, had risen to 948,000 in 1694, to 1,375,000 in 1704, to 2,000,000 in 1714, to 3,520,000 in 1724, to 4,947,000 in 1734, and to not less than 7,160,000 in 1742. . . . Retailers were deterred from vending them (spirituous liquors) by the utmost encouragement that could be given to informers. . . . The prospect of raising money by detecting their (unlicensed retailers') practices incited many to turn information into a trade; and the facility with which the crime was to be proved encouraged some to gratify their malice by perjury, and others their avarice; so that the multitude of informations became a public grievance, and the magistrates themselves complained that the law was not to be executed. The perjuries of informers were now so flagrant and common, that the people thought all informations malicious; or, at least, thinking themselves oppressed by the law, they looked upon every man that promoted its execution as their enemy; and therefore now began to declare war against informers, many of whom they treated with great cruelty, and some they murdered in the streets."[2]

Here, then, with absence of the looked-for benefit, there went production of unlooked-for evils, vast in amount. To recur to our figure, the original warp, instead of being made less by these direct blows, was made greater; while other distortions, serious in kind and degree, were created. And beyond the encouragement of fraud, lying, malice, cruelty, murder, contempt of law, and the other conspicuous crookednesses named, multitudinous minor twists of sentiment and thought were caused or augmented. An indirect demoralization was added to a direct increase of the vice aimed at.

Joining with the prevalent fallacy that results are proportionate to appliances, the general political bias has the further effect of fostering an undue faith in political forms. This tendency to ascribe every thing to the visible proximate agency, and to forget the hidden powers without which the agency is worthless—this tendency which makes the child gazing at a steam-engine ascribe every thing to the combina-

[1] Craik, in "Pictorial History," vol. iv., p. 853. [2] Ibid.

tion of parts it sees, not recognizing the fact that the engine can do nothing without the steam-generating boiler, and the boiler nothing without the water and the burning fuel, is a tendency which leads citizens to think that good government can be had by shaping public arrangements in this way or that way. Let us frame our state-machinery rightly, they urge, and all will be well.

Yet this belief in the innate virtues of constitutions is as baseless as was the belief in the natural superiorities of royal personages. Just as, of old, loyalty to ruling men kept alive faith in their powers and virtues, notwithstanding perpetual disproofs, so, in these modern days, loyalty to constitutional forms keeps alive this faith in their intrinsic worth, spite of ever-recurring demonstration that their worth is entirely conditional. That those forms only are efficient which have grown naturally out of character, and that, in the absence of fit character, forms artificially obtained will be inoperative, are well shown by the governments of trading corporations. Let us contemplate a typical instance of this government.

The proprietors of a certain railway-company (I am here giving my personal experience as one of them) were summoned to a special meeting. The notice calling them together stated that the directors had agreed to lease their line to another company; that every thing had been settled; that the company taking the lease was then in possession; and that the proprietors were to be asked for their approval on the day named in the notice. The meeting took place. The chairman gave an account of the negotiation, and the agreement entered into. A motion approving of the agreement was proposed, and seconded, and to some extent discussed—no notice whatever being taken of the extraordinary conduct of the board. Only when the motion was about to be put, did one proprietor protest against the astounding usurpation which the transaction implied. He said that there had grown up a wrong conception of the relation between boards of directors and bodies of proprietors; that boards had come to look upon themselves as supreme, and proprietors as subordinate, whereas, in fact, boards were simply agents appointed to act in the absence of their principals, the proprietors, and remained subject to their principals; that, if, in any private business, an absent proprietor received from his manager the news that he had leased the business, that the person taking it was then in possession, and that the proprietor's signature to the agreement was wanted, his prompt return would be followed by a result quite different from that looked for—namely, a dismissal of the manager for having exceeded his duty in a very astonishing manner. This protest against the deliberate trampling down of principles recognized by the constitution of companies met with no response whatever: not a solitary sympathizer joined in the protest, even in a qualified form. Not only was the motion of approval carried, but it was carried without any definite knowledge of the agreement itself. Nothing more

than the chairman's verbal description was vouchsafed: no printed copies of it had been previously circulated, or were to be had at the meeting. And yet, astonishing to relate, this proprietary body had been already once betrayed by an agreement with this same leasing company!—had been led to undertake the making of the line on the strength of a seeming guarantee, which proved to be no guarantee! See, then, the lesson. The constitution of this company, like that of companies in general, was purely democratic. The proprietors elected their directors, the directors their chairman; and there were special provisions for restraining directors and replacing them when needful. Yet these forms of free government had fallen into disuse. And it is thus in all cases. Save on occasions when some scandalous mismanagement or corruption, bringing great loss, has caused a revolutionary excitement among them, railway-proprietors do not exercise their powers. Retiring directors being reëlected as a matter of form, the board becomes practically a close body; usually some one member, often the chairman, acquires supremacy; and so the government lapses into something between oligarchy and monarchy. All this, observe, happening not exceptionally but as a rule, happens among bodies of men mostly well educated, and many highly educated—people of means, merchants, lawyers, clergymen, etc. Ample disproof, if there needed any, of the notion that men are to be fitted for the right exercise of power by teaching.

And now to return: Any one, who looks through these facts and facts akin to them for the truth they imply, may see that forms of government are valuable only where they are products of national *character*. No cunningly-devised political arrangements will of themselves do any thing. No amount of knowledge respecting the uses of such arrangements will suffice. Nothing will suffice but the emotional nature to which such arrangements are adapted—a nature which, during social progress, has evolved the arrangements. And wherever there is want of congruity between the nature and the arrangements—wherever the arrangements, suddenly established by revolution, or pushed too far in advance by reforming change, are of a higher type than the national character demands, there is always a lapse proportionate to the incongruity. In proof I might enumerate the illustrations that lie scattered through the modern histories of Spain, of South America, of Mexico. Or I might dwell on the lesson (before briefly referred to) presented us in France; where the recurring political cycle always shows us that new Democracy is but old Despotism differently spelt—where now, as heretofore, we find *Liberté, Egalité, Fraternité*, conspicuous on the public buildings, and now, as heretofore, have for interpretations of these words the extremest party-hatreds, vituperations and actual assaults in the Assembly, wholesale arrests of men unfriendly to those in power, forbiddings of public meetings, and suppressions of journals; and where now, as heretofore, writers, professing

to be ardent advocates of political freedom, rejoice in these acts which shackle and gag their antagonists. But I will take, instead, a case more nearly allied to our own.

For less strikingly, and in other ways, but still with sufficient clearness, this same truth is displayed in the United States. I do not refer only to such extreme illustrations of it as were at one time furnished in California; where, along with that complete political freedom which some suppose to be the sole requisite for social welfare, most men lived in perpetual fear for their lives, while others prided themselves on the notches which marked, on the hilts of their pistols, the number of men they had killed. Nor will I dwell on the state of society existing under republican forms in the West, where a white woman is burnt to death for marrying a negro, where secret gangs murder in the night men whose conduct they dislike, where mobs stop trains to lynch offending persons contained in them, where the carrying of a revolver is a matter of course, where judges are intimidated and the execution of justice often impracticable. I do but name these as extreme instances of the way in which, under institutions that nominally secure men from oppression, they may be intolerably oppressed —unable to utter their opinions and to conduct their private lives as they please. Without going so far we may find in the Eastern States proof enough that the forms of liberty and the reality of liberty are not necessarily commensurate. A state of things under which men administer justice in their own cases, are applauded for so doing, and mostly acquitted if tried, is a state of things which has, in so far, retrograded toward a less civilized state; for one of the cardinal traits of political progress is the gradual disappearance of personal retaliation, and the increasing supremacy of a ruling power which settles the differences between individuals and punishes aggressors. And, in proportion as this ruling power is enfeebled, the security of individuals is lessened. That security, lessened in this general way, is lessened in more special ways, we see in the bribery of judges, in the financial frauds by which many are robbed without possibility of remedy, in the corruptness of New York administration, which, taxing so heavily, does so little. And, under another aspect, we see the like in the doings of legislative bodies—in the unfair advantages which some individuals gain over others by "lobbying" in Crédit-Mobilier briberies, and the like. While the outside form of free government remains, there has grown up within it a reality which makes government not free. The body of professional politicians, entering public life to get incomes, organizing their forces, and developing their tactics, have, in fact, come to be a ruling class quite different from that which the Constitution intended to secure; and a class having interests by no means identical with public interests. The worship of the appliances to liberty, in place of liberty itself, needs continually exposing. There is no intrinsic virtue in votes. The possession of representatives is

not in itself a benefit. These are but means to an end; and the end is the maintenance of those conditions under which each citizen may carry on his life without further hindrances from other citizens than are involved by their equal claims—the securing to each citizen all such beneficial results of his activities as his activities naturally bring. The worth of the means is measured by the degree in which this end is achieved; and a citizen nominally having complete means, and but partially securing the end, is less free than another who uses incomplete means to more purpose.

But why go abroad for proofs of the truth that political forms are of worth only in proportion as they are vitalized by national character? We have proofs at home. I do not mean those furnished by past constitutional history—I do not merely refer to those many facts showing us that the nominal power of our representative body became an actual power only by degrees; and that the theoretically independent House of Commons took centuries to escape from regal and aristocratic sway, and establish a practical independence. I refer to the present time, and to actions of our representative body in the plenitude of its power. This assembly of deputies chosen by constituencies now so greatly extended, and therefore so well fitted, as it would seem, for guarding the individual, of whatever grade, against trespasses upon his individuality, nevertheless authorizes new trespasses upon his individuality. A popular government, just made more popular, has established, without the slightest hindrance, a law and an official organization that treat with contempt the essential principles of constitutional rule. Here is a brief account of the process:

On the 20th June, 1864, just before two o'clock in the morning, there was silently read a first time an act giving, in some localities, certain new powers to the police. On the 27th of that month, it was read a second time, also without comment—at what hour Hansard does not show. Just before two o'clock in the morning, on June 30th, there was appointed, without remark, a select committee to consider this proposed act. On the 15th July the report of this committee was received. On the 19th the bill was recommitted, and the report on it received—all in silence. On the 20th July it was considered—still in silence—as amended. And, on the 21st July, it was read a third time and passed—equally in silence. Taken next day to the House of Lords, it there, in silence equally profound, passed through all its stages in four days (? three). This act not proving strong enough to meet the views of naval and military officers (who, according to the testimony of one of the select committee, were the prompters of it), was in 1866 "amended." At one o'clock in the morning, on March 16th of that year, the act amending it was read a first time; and it was read a second time on the 22d, when the Secretary of the Admiralty, describing it as an act to secure the better health of soldiers and sailors, said: "It was intended to renew an act passed in 1864, with ad-

ditional powers." And now, for the first time, there came brief adverse comments from two members. On April 9th there was appointed a select committee, consisting mainly of the same members as the previous one—predominantly state-officers, of one class or other. On the 20th, the report of the committee was received. On the 26th, the bill was recommitted, just before two o'clock in the morning; and on the report there came some short comments, which were, however, protested against on the ground that the bill was not to be publicly discussed. And then, to end this brief history, observe the reception given to the only direct opposition raised. When, to qualify a clause defining the powers of the police, it was proposed to add, "that the justices before whom such information shall be made shall in all cases require corroborative testimony and support thereof, other than that of the members of the police force," this qualification was negatived without a word.

And now, what was this act, passed the first time absolutely without comment, and passed in its so-called amended form with but the briefest comments, made under protest that comments were interdicted? What was this measure, so conspicuously right that discussion of it was thought superfluous? It was a measure by which, in certain localities, one-half of the people were brought under the summary jurisdiction of magistrates, in respect of certain acts charged against them. Further, those by whom they were to be charged, and by whose unsupported testimony charges were to be proved, were agents of the law, looking for promotion as the reward of vigilance—agents placed under a permanent temptation to make and substantiate charges. And yet more, the substantiation of charges was made comparatively easy by only requiring a single local magistrate to be convinced, by the testimony, on oath, of one of these agents of the law, that a person charged was guilty of the alleged acts—acts which, held to be thus proved, were punished by periodic examinations of a repulsive kind, and forced inclusion in a degraded class. A House of Commons, elected by large constituencies, many of which are now chiefly composed of working-men, showed the greatest alacrity in making a law under which, in sundry districts, the liberty of a working-man's wife or daughter remains intact only so long as a detective does not give evidence which leads a magistrate to believe her a prostitute! And this bill, which, even had there been something like adequate reasons (which we have seen there were not) for dispensing with precautions against injustice, should, at any rate, have been passed only after full debate and anxious criticism, was passed with every effort to maintain secrecy; and this on the pretext that decency forbade discussion of it—all the while that Mordaunt-cases and the like were being reported with a fulness proportionate to the amount of objectionable details they brought out! Nor is this all. Not only do the provisions of the act make easy the establishment of charges by

men who are placed under a temptation to make them, but these men are guarded against penalties apt to be brought on them by abusing their power. A poor woman who proceeds against one of them, for making a groundless accusation ruinous to her character, does so with this risk before her: that, if she fails to get a verdict, she has to pay the defendant's costs (not taxed costs but *full* costs); whereas a verdict in her favor does not give her costs: only by a special order of the judge does she get costs! And this is the "even-handed justice" provided by a government freer in form than any we have ever had!"[1]

Let it not be supposed that in arguing thus I am implying that forms of government are unimportant. While contending that they are of value only in so far as a national character gives life to them, it is consistent also to contend that they are essential as agencies through which that national character may work out its effects. A boy cannot wield to purpose an implement of size and weight fitted to the hand of a man. A man cannot do effective work with the boy's implement: he must have one adapted to his larger grasp and greater strength. To each the implement is essential; but the results which each achieves are not to be measured by the size or make of the implement alone, but by its adaptation to his powers. Similarly with political instrumentalities. It is possible to hold that a political instrumentality is of value only in proportion as there exists a strength of character needful for using it, and at the same time to hold that a fit political instrumentality is indispensable. Here, as before, results are not proportionate to appliances; but they are proportionate to the force for due operation of which certain appliances are necessary.

One other still more general and more subtle kind of political bias has to be guarded against. Beyond that excess of faith in laws and in political forms which is fostered by awe of regulative agencies, there

[1] When, in dealing with the vitiation of evidence, I before referred to the legislation here named, I commented on the ready acceptance of those one-sided statements made to justify such legislation, in contrast with the contempt for those multitudinous proofs that gross abuses would inevitably result from the arrangements made. Since that passage was written, there has been a startling justification of it. A murder has been committed by a gang of sham-detectives (one of them a government employé); and the trial has brought out the fact that for the last three years the people of Lille have been subject to an organized terrorism which has grown out of the system of prostitute-inspection. Though, during those three years, five hundred women are said by one of these criminals to have fallen into their clutches—though the men have been blackmailed and the women outraged to this immense extent, yet the practice went on for the reason (obvious enough, one would have thought, to need no proof by illustration) that those aggrieved preferred to submit rather than endanger their characters by complaining; and the practice would doubtless have gone on still but for the murder of one of the victims. To some this case will carry conviction: probably not, however, to those who, in pursuance of what they are pleased to call "practical legislation," prefer an induction based on a Blue Book to an induction based on universal history.

is, even among those least swayed by this awe, a vague faith in the immediate possibility of something much better than now exists—a tacit assumption that, even with men as they now are, public affairs might be much better managed. The mental attitude of such may be best displayed by an imaginary conversation between one of them and a member of the Legislature.

"Why do your agents, with no warrant but a guess, make this surcharge on my income-tax return; leaving me to pay an amount that is not due, and to establish a precedent for future like payments, or else to lose valuable time in proving their assessment excessive, and, while so doing, to expose all my affairs? You leave me to choose between two losses, direct and indirect, for the sole reason that your assessor fancies, or professes to fancy, that I have understated my income. Why do you allow this? Why in this case do you invert the principle which, in cases between citizens, you hold to be an equitable one—the principle that a claim must be proved by him who makes it, not disproved by him against whom it is made? Is it in pursuance of old political usages that you do this? Is it to harmonize with the practice of making one whom you had falsely accused pay the costs of his defence, although in suits between citizens you require the loser to bear all the expense?—a practice you have but lately relinquished. Do you desire to keep up the spirit of the good old rulers who impressed laborers and paid them what they pleased, or the still older ones who seized whatever they wanted? Would you maintain this tradition by laying hands on as much as possible of my earnings and leaving me to get part of it back if I can: expecting, indeed, that I shall very likely submit to the loss rather than undergo the worry, and hindrance, and injury, needful to recover what you have wrongfully taken? I was brought up to regard the Government and its officers as my protectors; and now I find them aggressors against whom I have to defend myself."

"What would you have? Our agents could not bring forward proof that an income-tax return was less than it should be. Either the present method must be pursued, or the tax must be abandoned."

"I have no concern with your alternative. I have merely to point out that between man and man you recognize no such plea. When a plaintiff makes a claim but cannot produce evidence, you do not make the defendant submit if he fails to show that the claim is groundless. You say that, if no evidence can be given, nothing can be done. Why do you ignore this principle when your agents make the claim? Why from the fountain of equity comes there this inequity? Is it to maintain consistency with that system of criminal jurisprudence under which, while professing to hold a man innocent till proved guilty, you treat him before trial like a convict—as you did Dr. Hessel? Are your views really represented by these Middlesex magistrates you have appointed, who see no hardship to a man of culture in the seclu-

sion of a prison-cell, and the subjection to prison-rules, on the mere suspicion that he has committed a murder?"

"The magistrates held that the rules allowed them to make no distinctions. You would not introduce class-legislation into prison-discipline?"

"I remember that is one of the excuses; and I cheerfully give credit to this endeavor to treat all classes alike. I do so the more cheerfully because this application of the principle of equality differs much from those which you ordinarily make—as when, on discharging some of your well-paid officials who have held sinecures, you give them large pensions, for the reason, I suppose, that their expensive styles of living have disabled them from saving any thing; while, when you discharge dock-yard laborers, you do not give them compensation, for the reason, I suppose, that out of weekly wages it is easy to accumulate a competence. This, however, by the way. I am here concerned with that action of your political system which makes it an aggressor on citizens, whether rich or poor, instead of a protector. The instances I have given are but trivial instances of its general operation. Law is still a name of dread, as it was in past times. My legal adviser, being my friend, strongly recommends me not to seek your aid in recovering property fraudulently taken from me; and I perceive, from their remarks, that my acquaintances would pity me as a lost man if I got into your Court of Equity. Whether active or passive, I am in danger. Your arrangements are such that I may be pecuniarily knocked on the head by some one who pretends I have injured his property. I have the alternative of letting my pocket be picked by the scamp who makes this baseless allegation in the hope of being paid to desist, or of meeting the allegation in Chancery, and there letting my pocket be picked, probably to a still greater extent, by your agencies. Nay, when you have, as you profess, done me justice by giving me a verdict and condemning the scamp to pay costs, I find I may still be ruined by having to pay my own costs if he has no means. To make your system congruous throughout, it only needs that, when I call him to save me from the foot-pad, your policeman should deal me still heavier blows than the foot-pad did, and empty my purse of what remains in it."

"Why so impatient? Are we not going to reform it all? Was it not last session proposed to make a Court of Appellate Jurisdiction by appointing four peers with salaries of £7,000 each? And has there not been brought forward this session, even quite early, a Government-measure for facilitating appeals; so that the final judgments may not be postponed from year to year? Give us a little time, and we will make these renewals of litigation much easier."

"Thanks in advance for the improvement. When I have failed to ruin myself by a first suit, it will be a consolation to think that I can complete my ruin by a second with less delay than heretofore. Mean-

while, instead of this reform which you seem to think of primary importance, I should be obliged if you would diminish the occasion for appeals, by making your laws such as it is possible for me to know, or, at any rate, such as it is possible for your judges to know; and I should be further obliged if you would give me easier remedies against aggressions, instead of remedies so costly, so deceptive, so dangerous, that I prefer suffering the aggressions in silence. Daily I experience the futility of your system. I start on a journey expecting (foolishly, I admit) that, in conformity with the advertised times, I shall just be able to reach a certain distant town before night; but the train, being an hour late at one of the junctions, I am defeated—am put to the cost of a night spent on the way, and lose half the next day. I paid for a first-class seat that I might have space, comfort, and unobjectionable fellow-travellers; but, stopping at a town where a fair is going on, the guard, on the plea that the third-class carriages are full, thrusts into the compartment more persons than there are places for, who, both by behavior and odor, are repulsive. Thus in two ways I am defrauded. For part of the fraud I have no remedy; and, for the rest, my remedy, doubtful at best, is practically unavailable. Is the reply that, against the alleged breach of contract as to time, the company has guarded itself, or professes to have guarded itself, by disclaiming responsibility? The allowing such a disclaimer is one of your countless negligences. You do not allow me to plead irresponsibility if I give the company bad money, or if, having bought a ticket for the second class, I travel in the first. On my side you regard the contract as quite definite; but, on the other side, you practically allow the contract to remain undefined. And now see the general effects of your carelessness! Scarcely any trains keep their times; and the result of chronic unpunctuality is a multiplication of accidents and loss of life."

"How about *laissez-faire?* I thought your notion was, that the less Government meddled with these things the better; and now you complain that the law does not secure your comfort in a railway-carriage, and see that you are delivered at your journey's end in due time. I suppose you approved of the proposal made in the House last session, that companies should be compelled to give foot-warmers to second-class passengers."

"Really, you amaze me. I should have thought that not even ordinary intelligence, much less select legislative intelligence, would have fallen into such a confusion. I am not blaming you for failing to secure me comfort or punctuality. I am blaming you for failing to enforce contracts. Just as strongly as I protest against your neglect in letting a company take my money, and then not give me all I paid for, so strongly should I protest did you dictate how much convenience should be given me for so much money. Surely I need not remind you that your civil law in general proceeds on the principle

that the goodness or badness of a bargain is the affair of those who make it, not your affair; but that it is your duty to enforce the bargain when made. Only in proportion as this is done can men's lives in society be maintained. The condition to all life, human or other, is that effort put forth shall bring the means of repairing the parts wasted by effort—shall bring, too, more or less of surplus. A creature that continuously expends energy without return in nutriment dies; and a creature is indirectly killed by any thing which, after energies have been expended, habitually intercepts the return. This holds of associated human beings as of all other beings. In a society, most citizens do not obtain sustenance directly by the powers they exert, but do it indirectly: each gives the produce of his powers exerted in his special way in exchange for the produce of other men's powers exerted in other ways. The condition under which only this obtaining of sustenance, to replace the matter wasted by effort, can be carried on in society, is fulfilment of contracts. Non-fulfilment of contract is letting energy be expended in expectation of a return, and then withholding the return. The maintenance of contract, therefore, is the maintenance of the fundamental principle of all life under the form given to it by social arrangements. I blame you because you do not maintain this fundamental principle; and, as a consequence, allow life to be impeded and sacrificed in countless indirect ways. You are, I admit, solicitous about my life as endangered by my own acts. Though you very inadequately guard me against injuries from others, you seem particularly anxious that I shall not injure myself. Emulating Sir Peter Laurie, who made himself so famous by threatening to "put down suicide," you do what you can to prevent me from risking my limbs. Your great care of me is shown, for instance, by enforcing a by-law which forbids me to leave a railway-train in motion; and, if I jump out, I find that, whether I hurt myself or not, you decide to hurt me—by a fine.[1] Not only do you thus punish me when I run the risk of punishing myself, but your amiable anxiety for my welfare shows itself in taking money out of my pocket to provide me with various conveniences—baths and wash-houses, for example, and free access to books. Out of my pocket, did I say? Not always. Sometimes out of the pockets of those least able to afford it; as when, from poor authors who lose by their books, you demand *gratis* copies for your public libraries, that I and others may read them for nothing—Dives robbing Lazarus that he may give alms to the well-clad! But these many things you offer are things I do not ask; and you will not effectually insure me the one thing I do ask. I do not want you to ascertain for me the nature of the sun's corona, or to find a northwest passage, or to explore the bottom of the sea; but I do want you to insure me against aggression, by making the punishment of aggressors, civil as well as criminal, swift, certain, and costless to those injured. Instead

[1] *See* case in *Times*, December 11, 1872.

of doing this, you persist in doing other things. Instead of securing me the bread due to my efforts, you give me a stone—a sculptured block from Ephesus. I am quite content to enjoy only what I get by my own exertions, and to have only that information and those pleasures for which I pay. I am quite content to suffer the evils brought on me by my own defects—believing, indeed, that for me and all there is no other wholesome discipline. But you fail to do what is needed. You are careless about insuring to me the unhindered enjoyment of the benefits my efforts have purchased; and you insist on giving me, at other people's expense, benefits my efforts have not purchased, and on saving me from penalties I deserve."

"You are unreasonable. We are doing our best with the enormous mass of business brought before us: sitting on committees, reading evidence and reports, debating till one or two in the morning. Session after session we work hard at all kinds of measures for the public welfare—devising plans for educating the people; enacting better arrangements for the health of towns; making inquiries into the impurity of rivers; deliberating on plans to diminish drunkenness; prescribing modes of building houses that they may not fall; deputing commissioners to facilitate emigration; and so on. You can go to no place that does not show signs of our activity. Here are public gardens formed by our local lieutenants, the municipal bodies; here are light-houses we have put up to prevent shipwrecks. Everywhere we have appointed inspectors to see that salubrity is maintained; everywhere there are vaccinators to see that due precautions against small-pox are observed; and, if, happening to be in a district where our arrangements are in force, your desires are not well controlled, we do our best to insure you a healthy"—

"Yes, I know what you would say. It is all of a piece with the rest of your policy. While you fail to protect me against others, you insist on protecting me against myself. And your very failure to do the essential thing results from the absorption of your time in doing non-essential things. Do you think that your beneficences make up for the injustices you let me bear? I do not want these sops and gratuities; but I do want security against trespasses, direct and indirect—security that is real, and not nominal. See the predicament in which I am placed. You forbid me (quite rightly, I admit) to administer justice on my own behalf; and you profess to administer it for me. I may not take summary measures to resist encroachment, to reclaim my own, or to seize that which I bargained to have for my services: you tell me that I must demand your aid to enforce my claim. But demanding your aid commonly brings such frightful evils that I prefer to bear the wrong done me. So that, practically, having forbidden me to defend myself, you fail to defend me. By this my life is vitiated along with the lives of citizens in general. All transactions are impeded; time and labor are lost; the prices of commodities are

raised. Honest men are defrauded, and rogues thrive. Debtors outwit their creditors; bankrupts make purses by their failures, and recommence on larger scales; and financial frauds that ruin their thousands go unpunished."

Thus far our impatient friend. And now see how untenable is his position. He actually supposes that it is possible to get government conducted on rational principles! His tacit assumption is that, out of a community morally imperfect, and intellectually imperfect, there may in some way be had legislative regulation that is not proportionately imperfect! He is under a delusion. Not by any kind of government, established after any method, can the thing be done. A good and wise autocrat cannot be chosen or otherwise obtained by a people not good and wise. Goodness and wisdom will not characterize the successive families of an oligarchy, arising out of a bad and foolish people, any more than they will characterize a line of kings. Nor will any system of representation, limited or universal, direct or indirect, do more than represent the average nature of citizens. To dissipate his notion that truly-rational government can be provided for themselves by a people not truly rational, he needs but to read election-speeches, and observe how votes are gained by clap-trap appeals to senseless prejudices, and by fostering hopes of impossible benefits, while votes are lost by candid statements of stern truths and endeavors to dissipate groundless expectations. Let him watch the process, and he will see that when the fermenting mass of political passions and beliefs is put into the electoral still, there distils over not the wisdom alone, but the folly also—sometimes in the larger proportion. Nay, if he watches closely he may suspect that not only is the corporate conscience lower than the average individual conscience, but the corporate intelligence too. The minority of the wise in a constituency is liable to be wholly submerged by the majority of the ignorant; often ignorance alone gets represented. In the representative assembly, again, the many mediocrities practically rule the few superiorities: the few superior are obliged to express those views only which the rest can understand, and must keep to themselves their best and farthest-reaching thoughts, as thoughts that would have no weight. He needs but to remember that abstract principles are pooh-poohed in the House of Commons, to see at once that, while the unwisdom expresses itself abundantly, what of highest wisdom there may be has to keep silence. And, if he asks an illustration of the way in which the intelligence of the body of members brings out a result lower than would the intelligence of the average member, he may see one in those muddlings of provisions and confusions of language in Acts of Parliament, which have lately been calling forth protests from the judges.

Thus the assumption that it is possible for a nation to get in the shape of law something like embodied reason, when it is not itself pervaded by a correlative reasonableness, is improbable *a priori* and

disproved *a posteriori*. The belief that truly good legislation and administration can go along with a humanity not truly good, is a chronic delusion. While our own form of government, giving means for expressing and enforcing claims, is the best form yet evolved for preventing aggressions of class upon class, and of individuals on one another, yet it is hopeless to expect from it, any more than from other forms of government, a capacity and a rectitude greater than those of the society out of which it grows. And criticisms like the foregoing, which imply that its shortcomings can be set right by expostulating with existing governing agents or by appointing others, imply that subtlest kind of political bias which is apt to remain when the stronger kinds have been got rid of.

Second only to the class-bias, we may say that the political bias most seriously distorts sociological conceptions. That this is so with the bias of political party, every one sees in some measure, though not in full measure. It is manifest to the Radical that the bias of the Tory blinds him to a present evil or to a future good. It is manifest to the Tory that the Radical does not see the benefit there is in that which he wishes to destroy, and fails to recognize the mischiefs likely to be done by the institution he would establish. But neither imagines that the other is no less needful than himself. The Radical, with his impracticable ideal, is unaware that his enthusiasm will serve only to advance things a little, but not at all as he expects; and he will not admit that the obstructiveness of the Tory is a wholesome check. The Tory, doggedly resisting, cannot perceive that the established order is but relatively good, and that his defence of it is simply a means of preventing premature change; while he fails to recognize in the bitter antagonism and sanguine hopes of the Radical the agencies without which there could be no progress. Thus neither fully understands his own function or the function of his opponent; and, by as much as he falls short of understanding it, he is disabled from rightly understanding social phenomena.

The more general kinds of political bias distort men's sociological conceptions in other ways, but quite as seriously. There is this perennial delusion, common to Radical and Tory, that legislation is omnipotent, and that things will get done because laws are passed to do them; there is this confidence in one or other form of government, due to the belief that a government once established will retain its form and work as was intended; there is this hope that by some means the collective wisdom can be separated from the collective folly, and set over it in such way as to guide things aright—all of them implying that general political bias which inevitably coexists with subordination to political agencies. The effect on sociological speculation is to maintain the conception of a society as something manufactured by statesmen, and to distract attention from the phenomena of social evolution.

While the regulating agency occupies the thoughts, scarcely any thought is given to those astounding processes and results due to the energies regulated. The genesis of the vast productive and manufacturing and distributing agencies which has gone on spontaneously, often hindered, and at best only restrained, by governing powers, is passed over with unobservant eyes. And thus, by continually contemplating the power which keeps in order, and contemplating rarely, if at all, the activities that are kept in order, there is produced an extremely one-sided theory of society.

Clearly, it is with this as it is with the kinds of bias previously considered—the degree of it bears a certain necessary relation to the tempory phase of progress. It can diminish only as fast as society advances. A well-balanced social self-consciousness, like a well-balanced individual self-consciousness, is the accompaniment of a high evolution.

DOMESTIC ECONOMY OF FUEL.

By Captain DOUGLAS GALTON, C.B., F.R.S.

MY endeavor will be, to show that there may be obtained, from a much-diminished consumption of coal in fireplaces used for domestic purposes, all the advantages which have hitherto resulted from the wasteful expenditure which has prevailed.

I have no expectation of stating any thing that is actually new, because the functions and the attributes of heat and combustion have long been thoroughly discussed in their application to industrial objects. I hope, however, to draw attention to important considerations which govern the application of heat, and which are very generally neglected in fireplaces, in kitchen-ranges, and in most warming apparatus.

I think I may say, without hesitation, that the quantity of fuel now absolutely wasted in our houses amounts to at least five-sixths of the coal consumed. That is to say, if the greatest care and the best method of applying the heat were in all cases adopted, we could effect in heating and cooking all that we now effect, with one-sixth of the coal we now use; and, if, in the construction of our fireplaces and cooking apparatus, simple principles were recognized and ordinary care was used, we might without difficulty save from two-thirds to half of the coal consumed.

In my remarks on this question I intend to confine myself rather to the enunciation of the principles which should govern the application of heat for domestic purposes, than to give descriptions, except in a general way, of special appliances.

The inventors of apparatus for warming and cooking are so numerous, and the merits of a large number of inventions which have come into common use are of so negative a value, that it would not be fair to single out some individual instance for condemnation, and leave unnoticed other apparatus which possess equal defects and may be in equally extensive use. Mr. Edwards's very interesting and instructive treatise on domestic fireplaces clearly shows with what persistent perverseness the inventions which possess real merit have been almost invariably passed by. This result, I fear, is due mainly to the fact that architects and builders have not been penetrated with sound principles on the warming of our dwellings, and have encouraged the adoption of showy grates, based on false principles, instead of taking the trouble to make new designs of pretty grates based on sound principles of warming.

The question of the consumption of coal for domestic purposes divides itself into two branches:

1. The quantity required for warmth.
2. The quantity required for cooking.

The former is required only for the winter months, the latter is a permanent quantity during the year.

The waste of coal in domestic fireplaces is, however, no new question. It is quite eighty years since the subject was most fully treated of by Count Rumford, and afterward by Mr. Sylvester. They showed conclusively what enormous savings in fuel, for heating, cooking, and drying, were possible. Count Rumford's principles have never been generally applied, because the price of coals has ruled so low that householders have not much cared for economy. We hear Count Rumford's axioms now and then quoted by rival manufacturers in support of their newly-devised grates or kitchen-ranges; but, in many cases, the manufacturer, in the article he supplies, seems to be endeavoring to violate, rather than to follow, every axiom which Count Rumford ever laid down.

I do not mean to say that improvements have not taken place since Count Rumford's time, but the progress in the direction of economy has been very small, when we consider the great ingenuity displayed in devising new forms of apparatus. In respect of our fireplaces, our chief talent has been expended in providing a means of warming the outside air, and of polluting it by the smoke and soot we project into it.

The methods which have been adopted for warming houses fall under the several heads of—

1. Open fireplaces.
2. Close stoves (the German plan).
3. The Roman hypocaust, or floors warmed by direct action of fire.
4. Hot-water pipes, without ventilation.
5. Hot air warmed by a cockle, or by hot-water pipes.

The class of apparatus to be adopted in any country will vary with the climate. In England the climate is of so very changeable a nature, that the amount of heat required for comfort in a house varies from day to day. There are many days in the middle of winter when it is quite possible to sit in an unwarmed room; or, sometimes a warm morning is followed by a cold afternoon, when the sudden application of heat is desirable. It is probably for this reason that in England the open fireplace has, as a rule, held its own against all the proposals for warming houses by means of one central fire.

The open fireplace in ordinary use warms only by means of the direct radiation of the flame into the air of the room. It is the most primitive mode of warming, derived from the days when our ancestors inhabited caves. But these ancestors, by placing the fire in the centre of the floor of the cave, derived from it a larger portion of heat than we generally do, who place it against the wall of the room, and carry off the greater part of the heat up a flue separated from the room. The earlier fireplaces consisted of a large square brick opening, with a chimney carried up for the escape of smoke. The large square fireplace was adverse to the direct radiation into the room of the heat generated, and the large chimney removed from the room a very considerable quantity of air, which had necessarily to be replaced by cold air flowing into the room through all available apertures, and this created strong draughts.

Franklin, Count Rumford, and Sylvester, are the most prominent names of those who at an early period contributed improvements to the warming of our houses. The main principle of fireplace construction advocated by Count Rumford, eighty years ago, was, that the heat radiated from the fire directly into the room should be developed to the utmost. He brought the back of the fireplace as prominently forward as possible; he sloped the sides so as to reflect heat into the room; he advocated the use of fire-brick backs and sides instead of iron; he reduced the size of the chimney opening, so as to prevent the chimney carrying off the large quantity of warmed air it used to remove in his time. Our manufacturers of fireplaces have continued in the same groove. They have, undoubtedly, in some cases, largely developed the use of radiant heat. There are fireplaces, eminently successful as radiators of heat, of a circular or concave form, with polished iron sides, the fire being placed against a fire-brick back forming the apex of the concavity. So long as the concave surfaces are bright, the heat thrown out by them when a clear flame is burning is very great, but the gases from the flame pass directly off into the chimney while they are still at a very high temperature. The heat of the flame at that part will often be between 1,200° and 1,300° Fahr., and a very large proportion of this heat, to the extent of at least nine-tenths of that generated by the combustion of the fuel, is carried directly up the chimney.

One pound of coal is capable, if all the heat of combustion is utilized, of raising the temperature of a room, twenty feet square and twelve feet high, to ten degrees above the temperature of the outer air. If the room were not ventilated at all, and the walls were composed of non-conducting materials, the consumption of fuel to maintain this temperature would be very small, but, in proportion as the air of the room was renewed, so would the consumption of fuel necessary to maintain that temperature increase. If the volume of air contained in the room were changed every hour, one pound of coal additional would be required per hour to heat the inflowing air, so that, to maintain the temperature at ten degrees above that of the outer air during twelve hours, would require twelve pounds of coal.

The principle of the ordinary open fireplace is that the coal shall be placed in a grate, by which air is admitted from the bottom and sides to aid in the combustion of coal; and an ordinary fireplace, for a room of twenty feet square and twelve feet high, will contain from about fifteen to twenty pounds at a time, and, if the fire be kept up for twelve hours, probably the consumption will be about one hundred pounds, or the consumption may be assumed at about eight pounds of coal an hour.

One pound of coal may be assumed to require, for its perfect combustion, 150 cubic feet of atmospheric air; 8 lbs. would require 1,200 cubic feet; but, at a very low computation of the velocity of the gases in an ordinary chimney-flue, the air which would pass up the chimney at a rate of from 4 to 6 feet per second, or from 14,000 to 20,000 cubic feet per hour, with the chimneys in ordinary use, and I have often found a velocity of from 10 to 12 feet per second giving an outflow of air of from 35,000 to 40,000 cubic feet per hour—this air comes into the room cold, and when it is beginning to be warmed it is drawn away up the chimney, and its place filled by fresh cold air. A room 20 feet square and 12 feet high contains 4,800 cubic feet of space. In such a room, with a good fire, the air would be removed four or five times an hour with a moderate draught in the chimney, and six or eight times with a blazing fire; the air so removed would be replaced by cold air. The atmosphere of the room is thus being cooled down rapidly by the continued influx of cold air to supply the place of the warmer air drawn up the chimney. The very means adopted to heat the room produces draughts, because the stronger the direct radiation, or rather the brighter the flame in open fireplaces, the stronger must be the draught of the fire and the abstraction of heat. The only way to prevent draughts is to adopt means for providing fresh warmed air to supply the place of that removed.

The most natural way of providing warmed air is to utilize the excess of heat which passes up the chimney, beyond what is required for creating an adequate draught, and to use this heat to warm fresh air; and the warmed air should be admitted into the room in such places

as will enable it to flow most easily into the currents prevailing in the room. These considerations led to the construction of the ventilating fireplace, which has been so extensively used in barracks. This fireplace will keep a room at a given temperature with one-third of the quantity of fuel usually required in most ordinary fireplaces, and with less than one-half the quantity required in the very best-constructed radiating fireplaces.

The open ventilating fireplace, if properly constructed, is the simplest and most effectual means of warming and ventilating a single room, because it absorbs all spare heat from the chimney beyond what is necessary to create a draught; and, while it admits warmed air into the upper part of the room in an imperceptible current, the action of the fire draws air from the lower part of the room, and thus provides for a circulation of the warmed air toward the floor of the room.

The ventilating fireplaces invented by me, and now called by my name, but which have never been the subject of a patent, were a consequence of the efforts made by the late Lord Herbert and Miss Nightingale to improve the health of the army. The death-rate of the soldiers, when this question was taken up, was found to be larger than that of many unhealthy civil populations. Soldiers are, however, a body of men picked out as the healthiest members of the nation; they should, therefore, have had an exceptionally low death-rate in peace-time. A main element in the improvement of their health lay in improving the ventilation of their barrack-rooms. But soldiers, whenever they became aware of the existence of any fresh-air currents, insisted on closing the inlets. It was also made a *sine qua non* by the Government that the barrack-rooms should be warmed by open fireplaces; and, moreover, the Government required that the increased amount of ventilation declared to be necessary on medical grounds should be provided without any increase in the amount of fuel allowed. By the adoption of these fireplaces, and by the introduction of simple and improved arrangements for cooking the soldiers' food, the Government were enabled to effect a saving on the fuel supplied, instead of being obliged to incur a large increased expenditure on account of the additional ventilation introduced into the barrack-rooms. The manufacturer of these fireplaces informs me that he has supplied between 9,000 and 10,000 to the military departments up to this time.

The principle of warming by means of an open fireplace, or by means of a German stove or a Gill stove, is applicable to single rooms, that is to say, each room must have its own appliance, and each room may be self-contained as far as regards its heating and ventilation.

The close stoves employed in Germany use less fuel in warming the room than any open fireplace, but they are economical because the heat generated is not removed by the frequent renewal of the air. This element of their efficiency in warming, however, makes them most unhealthy.

The most recent improvements in the use of the German stove for warming have been introduced by Dr. Böhm, in the Rudolf Hospital at Vienna. He there warms fresh air by means of passages constructed in the fire-clay stoves, placed in the ward, and the fresh warmed air passes into the ward from the top of the stove. He provides flues of a large size, and proportioned to the size of the ward, from the level of the ward floor to above the roof, and the difference of temperature between the air in the ward and the outer air causes a sufficient current in these flues to ventilate adequately the ward. By this means the fresh warmed air, instead of passing off to the upper part of the ward and then away by flues there, is made to circulate toward the floor of the ward, thus bringing into action the principle by which the open fireplace is useful in ventilation. But this arrangement destroys one element of economy in the German stove, because the heat generated, instead of being left to pass slowly off into an unventilated room, is removed rapidly by the fresh air passed into the ward, and has, therefore, to be renewed at intervals, instead of, according to usual custom, the stove being left shut up for twenty-four hours to give off its heat slowly. The larger the supply of warmed air, the larger must be the consumption of fuel; and, if the heat is to be supplied economically, it must be through a good conducting medium; but the material of the German stove is a bad conductor of heat.

The old Roman system of warming by means of a fire under the floor produced a most agreeable and equable temperature, but it did not assist the ventilation, and it was not economical, in that the floor, being of tiles, was of a bad conducting material, and much of the heat was absorbed in the ground or surrounding flues. According to Pliny, the smoke was carried to the wood-house to be used in drying the wood for burning. I recently made an experiment to compare the effect of warming by means of a heated floor with the heating effect of a ventilating fireplace; the experiment lasted, with each mode of warming, for two days. It showed that, in the case of the warmed floors, the room was maintained at a temperature of about 18° above the temperature of the outer air with an expenditure of 56 lbs. of coal and 112 lbs. of coke, while with the ventilating fireplace the expenditure was only 75 lbs. of coal; the cost being 3*s.* 4*d.* for the warmed floor as compared with 1*s.* 4*d.* for the ventilating fireplace.

A more complete plan of warming a building is by means of a fire from which the heat is conveyed, either by hot-water pipes or hot air, to the various parts of the building.

Warming by means of air conveyed by flues to various parts of the building, will answer, as a rule, in ordinary existing houses, best in connection with open fireplaces, which draw in the warmed air to the various rooms, because there must be some means of forcing or drawing the warmed air into the house, and it would not be convenient to

keep a steam engine in an ordinary house to pump in the warmed air. These open fireplaces would then, however, be wasting the spare heat which each fireplace sends up its own chimney; but, on the other hand, very much smaller fires would be needed, to keep the rooms warm, than when the rooms are not supplied with fresh warmed air. Theoretically, however, it can be shown that if we are prepared to give up open fireplaces, and arrange our houses on the plan of having flues which would draw off the air from near the floors of our rooms, and which would also warm fresh air, heated from a central fire, to be constantly admitted near the ceilings, and if the climate were such as to make us desire to have the system in continuous operation, such a system would probably be by far more economical of fuel than open fireplaces, because the fuel used could then be made to do its full duty. The variations of our climate and the low price of fuel, which have hitherto prevailed, have prevented such systematic arrangements from being adopted in this country.

The plan of carrying the heat from the fire to the air to be warmed by means of hot-water pipes affords also a very economical method of warming air, because the best-constructed hot-water apparatus will enable the full heating value to be got out of the fuel. Fuel may be consumed to far greater advantage in a close furnace than in any open grate, because the admission of air for the combustion of the fuel can be regulated to any required extent. The heating surface of the boiler may also be so arranged as to absorb a very large proportion of the heat generated by the fire.

But in deciding on the amount of heat in hot-water pipes which is most favorable to economy, the following considerations occur: At least twice the quantity of air which is strictly necessary by theory passes through the fire in the best-constructed furnaces. In an ordinary grate this consumption is enormously increased. Each part of oxygen supplied by the air and necessary for combustion is accompanied by four parts of nitrogen, which is of no value for combustion. Consequently, if twice as much oxygen passes through the fire as is strictly necessary, we have one part which combines with carbon and produces combustion, and nine parts which, being inert, must act, in the first place, to lower the temperature of the fire, and, secondly, to carry a larger amount of unutilized heat up the chimney. Moreover, when water is heated sufficiently to generate steam, each particle of water converted into steam absorbs or makes latent 960° Fahr. of temperature. In experiments on the evaporation of water, the temperature of the gases passing off in the chimney was ascertained to vary from 430° to 530°, diminishing to 415° at the top of a flue 35 feet high, with the dampers open; and about 380° at the bottom of the flue with the dampers closed. With a boiler of which the temperature of the water is maintained at 200° without evaporation, the temperature of the flue need not exceed from 230° to 240°.

It is clear from these considerations, that, in order to insure the maximum effect from the fuel, the heating surface of the pipes should be sufficiently large to warm all the air required without its being necessary to raise the temperature of the water in the boiler to any great extent, and the proportion between the boiler-surface and the pipe-surface, that is to say, between the surface which absorbs heat, and the surface which gives out heat, should be such as to render it unnecessary for the fire to be forced, because, the lower the temperature at which the gases from the fire pass off up the chimney, the greater will be the economy.

In order to show the waste which results from forcing the boiler, i. e., from passing the gases into the flue at a high as compared with a low temperature, I will give an instance of one experiment. The proportion of heating surface in the boiler to the heating surface of the pipes is assumed by some manufacturers as 1 to 100, or, when great heat is required, 1 to 40. An experiment made on 4,000 feet of pipe, heating certain greenhouses by a wagon-shaped boiler with 40 square feet of heating surface, showed that a certain temperature was kept up for 8 hours with 8 bushels of coal; but when, by the addition of another boiler, the heating surface of the boiler was increased to 80 square feet, the temperature could be maintained for the same period with 4 bushels of coal. The outer temperature was the same on the two days.

On these grounds it is not so economical, so far as the consumption of fuel is concerned, to use steam instead of water, either water heated to a high temperature under pressure, or to heat air for warming purposes, because the gases from the fire employed to produce the higher degree of heat will pass off at a high temperature, and the heat they contain be wasted. On the other hand, the capital outlay required, where highly-heated pipes are used, is smaller than with hot-water pipes, because a smaller heating surface, and therefore smaller pipes, will suffice when the temperature is high; and, moreover, a very small pipe will convey steam to any required place, whereas with hot water, at a relatively low temperature, much larger pipes are required. It follows that where the price of fuel makes it necessary to reduce the permanent annual expenditure, the original capital outlay must be increased. There is a further consideration in regard to economy with hot-water pipes, steam-heating, and all appliances for warming buildings from a central fire, viz., that if the heat has to be conveyed for long distances before its useful application comes into force, very much heat is lost, and consequently fuel is wasted. On the other hand, against the saving which would result from a more immediate application of the heat to the place to be warmed, there is to be weighed the diminished expense of attendance consequent upon the use of one fire instead of several fires, each with its attendance and supply of fuel. There remains one source of economy to be applied to close grates used for heating water, which has not yet been adopted. I mean the applica-

tion of some of the heat which is passing into the chimney to warm the air which feeds the fire. Theoretical considerations show that an advantage of from six to nine per cent. might be obtained from this source, and the experiments which I have made bear out this result.

But, after we have designed the most effective arrangements for economizing the fuel which warms our dwellings, if that object is to be fully secured, we must arrange to retain the heat in our houses. The architect should devote to these considerations the same care which he now is frequently satisfied with bestowing upon the beauty of the design for a building. The arrangements of the plan should be adapted to the retention of heat. All portions of houses exposed to the air should be formed of materials which are found to be the slowest conductors of heat. Whatever may have been the mistakes of the manufacturers of fire-grates or kitchen-ranges, the nation has latterly very much disregarded the means of retaining heat in the house. The uniform model house of the speculating builder is constructed with thin walls, thin glass windows, ill-fitting casements, and a roof of slates, with nothing under them. The old half-timbered house was warm, because it had an air space between the inner and outer skin; the brick-built, stone-faced house is warm because it has, so to say, a double wall. In modern houses it has long been shown that, without much increased expense, the use of walls built hollow will keep the rooms effectually warm and dry, and yet this mode of building is the exception rather than the rule, possibly because it gives the architect or the builder a little additional trouble. A slated roof, if ill-constructed, is a material agent in allowing of the escape of heat, because there is necessarily an inlet for air where the slates overlap. The old thatched roof, although most dangerous in cases of fire, was a great preserver of heat. In well-built modern houses the slates are laid on felt, which is laid on close boarding, and this arrangement keeps the house warm in winter and cool in summer. As regards the windows, glass ranks high as a non-conductor of heat, and the effect of using thick glass, instead of the very thin glass so often seen, is very largely to economize the heat. Evidence of the cooling effect on the air of a room of a window of thin glass is afforded by the cold draught which any one perceives when sitting on a cold day near a closed window of thin glass. Proposals have been often made to glaze a window with double panes, and no doubt such a plan is a good means of retaining heat in the room, but the inside of the glass between the panes will in time become dirty, and then it can only be cleansed by removing one of the panes. A more convenient, but more expensive, plan is to adopt the system, which prevails universally in the northern parts of Europe, of a double casement.

It is not, however, my object here to give a treatise on building. The conclusion which I would draw from these various considerations is, that, if we desire to economize to the utmost the daily expenditure

of fuel, we must increase our outlay of capital. So long as coal was cheap, it may have been better worth the while of the individual consumer to employ coal wastefully rather than spend money upon the arrangements for economizing heat. On the other hand, when coal is dear, the daily expense from the waste of fuel will induce a capital outlay to secure economy of heat.—*Journal of the Society of Arts.*

THE DRIFT-DEPOSITS OF THE NORTHWEST.

By N. H. WINCHELL,
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I. *Nature of the Drift.*

IN the March number of this journal, Mr. Elias Lewis calls attention to the occurrence of bowlder-like masses of clay in stratified gravel, at Brooklyn, N. Y. In the progress of the geological survey of Ohio, similar masses of gravelly clay were met with in the northwestern portion of the State, lying in the stratified gravel and sand that constitute the long ridges which have often been pronounced "lake-beaches." These occurrences, and a great many others that militate against the popular theory that those ridges are attributable to the action of the waters of Lake Erie, and the stratification of the drift generally over the "interior continental basin" to the action of a wide-spread lake, or of the ocean, made it necessary to reinvestigate the drift-deposits thoroughly, for the purpose of deducing from the drift itself such a theory of its origin as would stand the application of all the facts. Such reëxamination has resulted, in the opinion of the writer, in the confirmation of the glacier theory of Prof. L. Agassiz, and the consequent abandonment of the iceberg theory of Peter Dobson. It has also shown the baselessness of the assumption of some who would extend the Champlain epoch of Prof. J. D. Dana, so as to bring on, after the period of the glacier, a submergence of the continent beneath the ocean. It is proposed to review, in a non-technical way, the phenomena of the drift of the Northwest, and to offer a few thoughts on the *glacier theory*, and its application to the explanation of those phenomena.

In general, the term drift applies to whatever lies on the surface of the rocky framework unconsolidated, whatever be its origin or lithological character. Glacial drift is that which has been transported by the agency of ice, or by ice and water, from regions farther north, and spread over the surface of the country. It may embrace bowlders, gravel, and clay. These substances may be arranged in stratification, and nicely assorted, or they may be confusedly mixed.

When stratified and assorted, they have sometimes been denominated *modified drift;* when not assorted, *unmodified drift.* But these terms require considerable caution in their use, since they have been differently applied by different writers, depending somewhat on the supposed cause of the assortment witnessed in *modified drift*, and since the assorted and non-assorted portions of the drift are not uniform, either in their positions in the great mass of the deposit, or in the characters they generally possess.

The character and nature of the drift in the Northwest are very largely misapprehended. This is true, not only among those who might not strictly be regarded as geologists—such as surveyors, engineers, lecturers, and public *literati*—but even among those who have given considerable attention to the study of fossils and rocks. These misapprehensions, so generally spread among the people, are largely due to the industry of the authors of certain theories concerning its origin, in spreading their views before the public. A plausible theory, moreover, has a great influence in its own favor.

A pretty careful study of the drift in this State,[1] and in others embraced in what may be called the *continental basin*, east of the Mississippi, has shown it to consist, in general, of the following parts, in descending order:

No. 1. *Surface Soil.*—This, of course, presents all the varieties due to local influences. Over large portions of the Northwest it is a fertile black loam, highly arenaceous, and supplied with a considerable proportion of carbon in a state of minute subdivision. This arenaceous loam passes into a more gravelly loam on the brows of knolls and in rolling land. It is also sometimes replaced by a gravelly clay. This is the case in large portions of the State of Michigan, and in Central and Southern Ohio. This is the fact in Northern Indiana and in Central Minnesota. The gravel prevails in wooded and rolling districts. In treeless districts the sandy element is more common, making a black loam. In valleys and along streams the soil is alluvial. It is invariably fine, nearly free from stones and bowlders, and very fertile. It is what is popularly known as "made land," and comprises those parts of the drift of the highlands that are susceptible of transportation by running water. That which is known as the "bluff-formation," lining the Mississippi, both in Minnesota and in the States farther south, consists of alluvium, washed into the great valley by innumerable streams from the adjoining country, at a time when the volume of the river was immensely greater than now. The same materials are now spread over the farms of Southern Minnesota, over much of Iowa and Illinois, over Northern Missouri and all the Far West, to the Rocky Mountains. It lies there also in the form of fine sand, and constitutes the *loam* already described. Its thickness at points remote from the river is dependent on the facilities for natural drainage and wash. It may be

[1] Minnesota.

six inches, or it may be six feet. Along the banks of the Mississippi it presents, not infrequently, perpendicular sections of six hundred feet. Its firmness in maintaining its position in such exposed bluffs is due to the infiltration of the cements of lime and iron while in the process of deposition, or subsequently. It is more largely developed along the Missouri than along the Mississippi. There are other places where the surface-soil may be peaty, from the preservation of dead vegetation. Extensive level tracts, that are submerged a large part of the year, may present a peaty soil. Very often also in such peaty places there will be found patches of highly-calcareous soil, resulting from the accumulation of fresh-water shells, or from the precipitation of the carbonate of lime from waters that enter the marsh from limestone districts.

But, whatever the character of the surface-soil, it must be borne in mind that it is accidental, and is always superinduced by causes that have operated since the advent of the drift. Its influence is strictly superficial, rarely exceeding three feet below the natural surface.

No. 2.—We come now to consider that which lies below the surface-soil. If we omit from this enumeration the "bluff-formation," and the alluvium of other streams which sometimes has a considerable thickness, we shall have two different substances, equally pertaining to the drift, and occupying the same relative position in different localities, that claim notice:

1. A *clay* subsoil.
2. A *gravel* or *sand* subsoil.

Now, although these are mentioned as appearing first beneath the surface-soil, it must not be understood that they appear there invariably, nor even usually. It is probably true that throughout the greater portion of the Northwest they are entirely wanting, and that feature of the drift prevails which will next be considered. They are mentioned here because they constitute an essential part of the drift, and must not be overlooked in giving its character and composition.

By the first, here denominated a *clay* subsoil, is not meant a gravelly clay, or one in which stones are present. It is, rather, a close, plastic, fine clay, with little observable sand. It is impervious to water, and is benefited by artificial drainage. It prevails in much of Southwestern Michigan and Northwestern Ohio. It occupies a large tract in Northeastern Illinois and Northwestern Indiana. It also probably underlies the Red River flats in Minnesota, and perhaps a belt of land rudely conforming to the shore of Lake Superior at its western extremity. When shafts are sunk through this clay subsoil, so as to reveal its composition and arrangement, it is seen to be handsomely laminated horizontally. The individual layers are separated by thinner layers of fine sand. Those of clay are usually about two inches in thickness, but may be no more than one-eighth of an inch; the layers of sand are rarely more than half an inch in thickness, and are apt to

be less than an eighth. The aggregate thickness of these alternating layers of clay and sand is sometimes a hundred feet or more. Let it be noticed that these areas of *clay subsoil* are those in which there is a gentle descent, and drainage to the north or northeast into some one of the great interior lakes of fresh water. The relation this fact bears to the origin of this *clay subsoil* will be considered farther on.

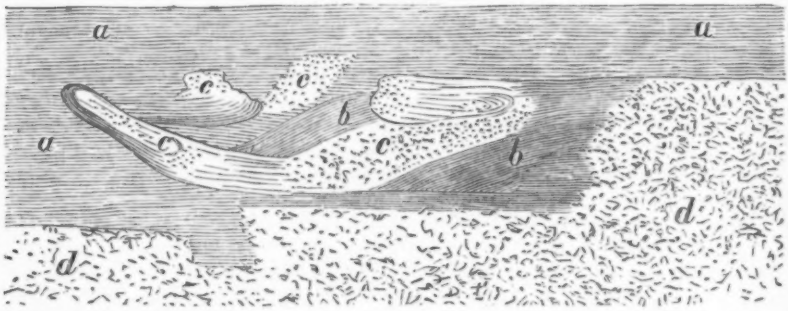
The *gravel* or *sand* subsoil is that which is found in some tracts of rolling land where the drift is heavy, and at points more remote from the valleys of northward drainage, or in the upper portions of those valleys. As a general rule, when present, it will be found on a higher level than that in which the subsoil is clay. It pertains to the interior country like the central part of the southern peninsula of Michigan, the central and southern portions of Ohio, Indiana, and Illinois, and some parts of Central and Northern Minnesota. The area and location of this kind of subsoil are more irregular and more uncertain than the areas of clay subsoil. Such gravel and sand deposits often lie in belts traceable for a great many miles, especially where the general surface is smooth, and the underlying rock of uniform hardness, the country adjoining being, on either side of the belt, one of a clay subsoil, or one formed by No. 3. Such belts are sometimes three or four rods wide, or they may be much wider, and are rolling and slightly raised above the adjoining clay land. Sometimes, instead of lying in belts, such rolling, gravelly land is spread out over areas of no definite shape or limit. The sand or gravel constituting the subsoil in these rolling tracts is, like the clay of the clay subsoil, stratified and assorted. But the layers here are rarely horizontal. They show the most various alternation and change of dip. No two sections could be taken that would give the same succession of parts. The sand sometimes lies in heavy deposits fifteen or twenty feet thick, with lines of deposition running in curving and vanishing layers in all directions. Sudden transitions occur from sand to gravel, or from gravel to bowlders. Sometimes, also, bowlders are found embedded in the gravel; again, nests of bowlders are seen isolated from the rest, and packed closely by themselves. There is also very often a mingling of gravel and sand, with no clay, without stratification, as if the two had been dumped together, after having been first thoroughly washed and assorted. Occasionally, also, in this stratified gravel and sand, may be seen irregular masses of gravelly clay or hard-pan, comparable to those mentioned by Mr. Lewis at Brooklyn. Such gravelly clay sometimes embraces stones of considerable size. Near the bottom of this stratified gravel and sand there are also, often, upward protrusions of the underlying member of the drift (No. 3), somewhat wedge-shaped or oblique, so as to embrace on the lower side a portion of the stratified gravel and sand. Again, the line of junction between the gravel and sand, and the hard-pan of No. 3, may be marked by an unusual accumulation of coarse drift materials, such as stones and bowlders. These may be mostly surrounded by

the gravel and sand of No. 2, or they may be mostly embedded in No. 3. The thickness of No. 2 is exceedingly variable. It is usually less than forty feet in level tracts, but it may be more than a hundred, depending on the duration of the cause that brought it there, and its operation at that point. It sometimes probably entirely replaces No. 3 and No. 4, and lies on the rock. The bowlders found within it are generally not scratched, but sometimes they are scratched, evidently by glacier-action. A great number of glaciated bowlders in this member of the drift have been seen at an excavation near the Falls of St. Anthony.

The following diagrams, Figs. 1 and 2, will express more fully the arrangement of the strata in this member of the drift, and give an idea of the manner of union with the succeeding member below. Fig. 1 is sketched from Nature, and shows a section of the laminated clay exposed in a railroad-cut near Toledo, Ohio:

FIG. 1.

NATURAL SURFACE.



SECTION OF THE LAMINATED CLAY (CLAY SUBSOIL), TOLEDO, OHIO, SHOWING ITS JUNCTION WITH THE HARD-PAN OF THE DRIFT.

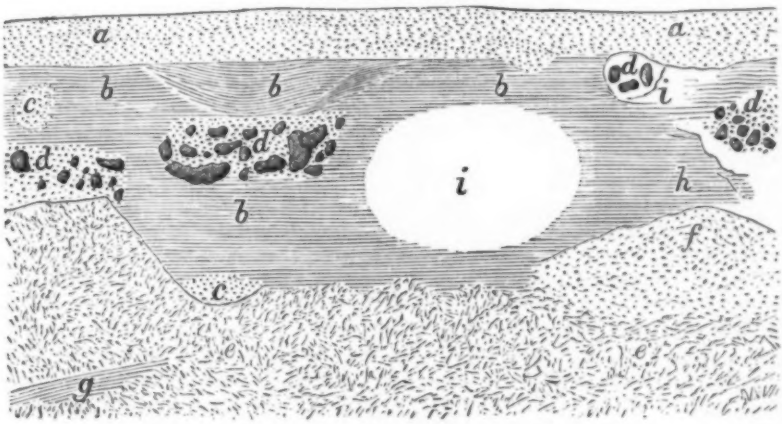
a. Horizontal laminations of fine clay and sand.
b. Oblique laminations of fine clay and sand.
c. Detached masses of hard-pan clay, variously mingled and united with the laminated clay.
d. The upper portion of the great hard-pan sheet.

Fig. 2 is also sketched from Nature, and represents the alternation of parts as seen in No. 2, and manner of junction with No. 3 at the Falls of St. Anthony. No. 2 here consists of the stratified gravel and sand which constitutes the surface of the drift (immediately below the soil) in large portions of the State of Michigan, Central and Southern Ohio, Northern Indiana, and Central Minnesota. It also forms the principal component of the well-known ridges in Northwestern Ohio, popularly but erroneously styled "lake-beaches." The materials are usually much water-worn, but, at the Falls of St. Anthony, many of the bowlders embraced in No. 2 are conspicuously glacier-marked, a circumstance which plainly indicates the agency which transported and deposited the whole mass in which they occur.

No. 3.—The great deposit that follows No. 2, whether it be of clay or of gravel and sand, is that designated in common usage "hard-pan." It constitutes the chief member of the drift throughout the Northwest. It is rarely found entirely wanting, whereas the foregoing are very often wanting. It seems to be the parent member of which the former two are offshoots, or modifications. It sometimes has a thickness of more than two hundred feet, and rises to the surface forming the basis of the soil. It consists of a heterogeneous mixture of clay and gravel-stones, with bowlders of northern origin. It is nearly impervious to water, and occasionally, but rarely, shows a rude arrangement in alternating bands, as if, in a plastic state, it had been folded upon itself. Such arrangement discloses no assortment of the

FIG. 2.

NATURAL SURFACE.



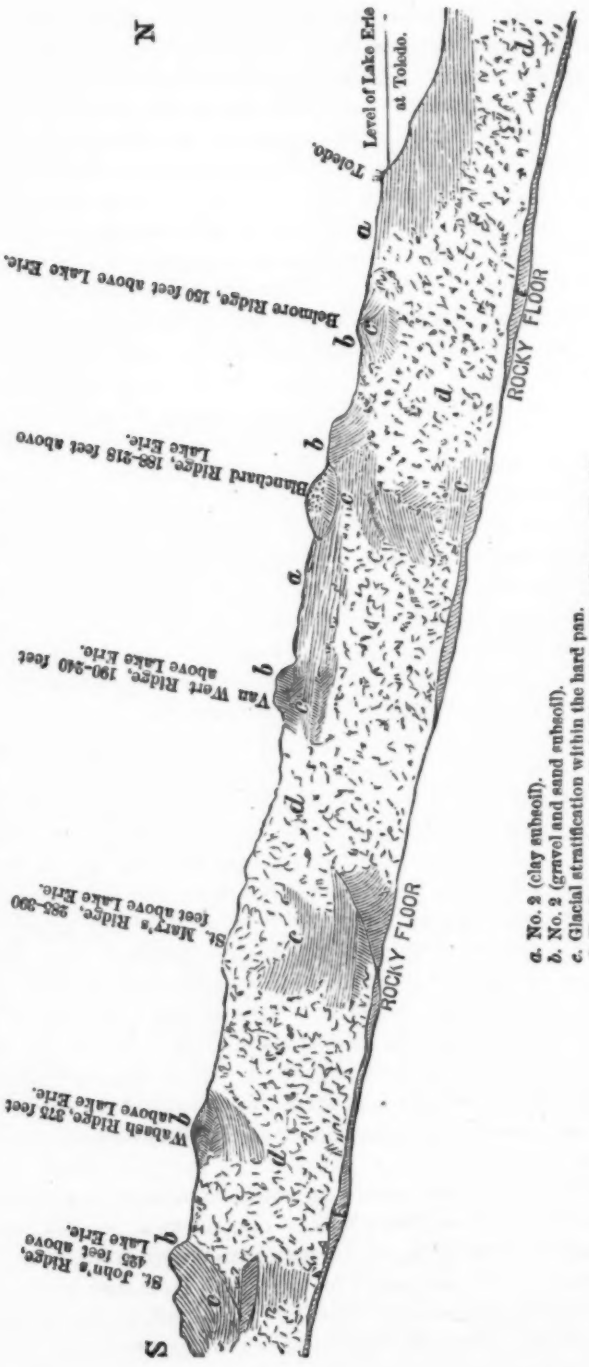
SECTION OF THE DRIFT AT THE FALLS OF ST. ANTHONY.

a. "Bluff-formation," alluvial, unstratified, mostly sand.....6– 8 feet.
b. Stratified, fine sand.....6–20 do.
c. Gravel and stones, in isolated pockets, unstratified.
d. Bowlders and gravel, the former distinctly glaciated.
e. Hand-pan, or "unmodified" drift.....seen 10 do.
f. Massive, fine sand.
g. Rude arrangement within the hard-pan.
h. Sandy and stony, with rude stratification.
i. Hid from view by sliding sand.

materials that can be likened to the assortment seen in No. 2. The bowlders embraced in this member of the drift almost invariably show glaciated surfaces. Although apt to be more abundant near the bottom of the deposit, they are not confined to it, as is sometimes stated, but occur throughout the whole. This deposit of hard-pan sometimes encloses lenticular masses of assorted materials. It has even been seen to overlie a considerable thickness of fine stratified sand the extent of which could not be ascertained. In general, however, it is one compact, uniform mass, varying slightly in the proportions of its different parts, from State to State, according to the readiness of supply of any

Fig. 3.

GENERAL SECTION OF THE DRIFT FROM TOLEDO, OHIO, TO SHELBY COUNTY, OHIO.


N
S
Toledo.
Level of Lake Erie at Toledo.
Bellmore Ridge, 150 feet above Lake Erie.
Blanchard Ridge, 188–218 feet above Lake Erie.
Van Wert Ridge, 190–340 feet above Lake Erie.
St. Mary's Ridge, 285–390 feet above Lake Erie.
Wabash Ridge, 375 feet above Lake Erie.
St. John's Ridge, 425 feet above Lake Erie.
ROCKY FLOOR
ROCKY FLOOR
a. No. 2 (clay subsoil).
b. No. 2 (gravel and sand subsoil).
c. Glacial stratification within the hard pan.
d. Hard pan, glacier drift, holding striated bowlders.—(No. 3.)
e. Gravel, sand, and bowlders, holding water.—(No. 4.)

one of them. For example, in Ohio (Northwestern Ohio) it is very close and clayey, the upper part being free from bowlders and stones. In Minnesota (Central Minnesota), the stones and bowlders are more generally disseminated throughout the whole, and it shows much more sand. Hence, in the latter State it will allow the slow passage of water through it—a fact exceedingly fortunate for the agricultural capacity of the soils that are based on it.

Perhaps there should be added to this description of the drifts another member, which may be denominated No. 4.

No. 4.—This, however, is so inconstant and so often runs into the last, that it is hardly worthy of special designation. When present, it lies below No. 3, and immediately over the rock. It consists of gravel and bowlders, more or less mingled with clay. It is the great water-reservoir that supplies deep wells, and through it there is a constant slow drainage into deep valleys and excavations. It gives rise to springs at the base of the river-bluffs, and to artesian wells, when the confining stratum of hard-pan above is penetrated in regions of favorable slope. In Northwestern Ohio is a most wonderful series of artesian wells that depend entirely upon this fortunate combination of circumstances. This member of the drift sometimes consists largely of assorted materials, as sand and gravel. This is indicated by the issuing of considerable quantities of such sand from artesian wells that penetrate it, when the force of the current of water is sufficient to bring it to the surface. Instances have occurred of the collapse of the overlying clay and hard-pan, on the removal in this way of large quantities of sand. Along the upper side of this member, the materials are apt to be firmly cemented by iron and carbonate of lime, into a very firm, even rocky crust. Such cemented gravel and sand is seldom over two feet thick, yet well-borers, on reaching it, often mistake it for the bed-rock. They pass through it, and usually find a copious flow of excellent water. The announcement is then promulgated that *that well was drilled through the rock*. Hence it is a popular error that, in order to obtain water of the purest quality, it is necessary to sink a well "through the rock." This member, though, is not always found in penetrating the drift to the rock. It may be here stated, also, that, when No. 4 is present, the bed-rock does not show so plainly the marks of glaciation; but, when No. 3 extends to the rock, the surface of the bed-rock is almost invariably marked with the well-known glacier-etchings.

Having taken this survey of the component parts of the drift, it will be well to bring them into a general view, as illustrated by the preceding diagram (Fig. 3), in which the figures represent the same members as in the previous illustrations. It shows a general section of the drift, from Toledo to Shelby County, Ohio, and is based on extended observations, the results of which are to appear in the forthcoming reports of the "Geological Survey of Ohio." The six ridges

here represented in profile can be traced from 30 to 130 miles, running into Indiana. Toward the north, in Michigan, they unite by convergence, but one or two being visible in that State. Another article will treat the interesting question of the origin of the drift.

SOME OBSERVATIONS ON NIAGARA.[1]

By Prof. JOHN TYNDALL, LL.D., F.R.S.

IT is one of the disadvantages of reading books about natural scenery that they fill the mind with pictures, often exaggerated, often distorted, often blurred, and, even when well drawn, injurious to the freshness of first impressions. Such has been the fate of most of us with regard to the Falls of Niagara. There was little accuracy in the estimates of the first observers of the cataract. Startled by an exhibition of power so novel and so grand, emotion leaped beyond the control of the judgment, and gave currency to notions regarding the water-fall which have often led to disappointment.

A record of a voyage in 1535, by a French mariner named Jacques Cartier, contains, it is said, the first printed allusion to Niagara. In 1603 the first map of the district was constructed by a Frenchman named Champlain. In 1648 the Jesuit Rageneau, in a letter to his superior at Paris, mentions Niagara as "a cataract of frightful height."[2] In the winter of 1678 and 1679 the cataract was visited by Father Hennepin, and described in a book dedicated "to the King of Great Britain." He gives a drawing of the water-fall, which shows that serious changes have taken place since his time. He describes it as "a great and prodigious cadence of water, to which the universe does not offer a parallel." The height of the fall, according to Hennepin, was more than 600 feet. "The waters," he says, "which fall from this great precipice do foam and boil in the most astonishing manner, making a noise more terrible than that of thunder. When the wind blows to the south, its frightful roaring may be heard for more than fifteen leagues." The Baron la Hontan, who visited Niagara in 1687, makes the height 800 feet. In 1721, Charlevoix, in a letter to Madame de Maintenon, after referring to the exaggerations of his predecessors, thus states the result of his own observations: "For my part, after examining it on all sides, I am inclined to think that we cannot allow it less than 140 or 150 feet"—a remarkably close estimate. At that time, viz., a hundred and fifty years ago, it had the shape of a horse-shoe, and reasons will subsequently be given for holding that this

[1] A lecture before the Royal Institution, delivered April 4, 1873.

[2] From an interesting little book presented to me at Brooklyn by its author, Mr. Holly, some of these data are derived: Hennepin, Kalm, Bakewell, Lyell, and others, I have myself consulted.

has been always the form of the cataract from its origin to its present site.

As regards the noise of the cataract, Charlevoix declares the accounts of his predecessors, which, I may say, are repeated to the present hour, to be altogether extravagant. He is perfectly right. The thunders of Niagara are formidable enough to those who really seek them at the base of the Horseshoe Fall; but on the banks of the river, and particularly above the fall, its silence, rather than its noise, is surprising. This arises, in part, from the lack of resonance, the surrounding country being flat, and therefore furnishing no echoing surfaces to reënforce the shock of the water. The resonance from the surrounding rocks causes the Swiss Rouss at the Devil's Bridge, when full, to thunder more loudly than the Niagara.

On Friday, the 1st of November, 1872, just before reaching the village of Niagara Falls, I caught, from the railway-train, my first glimpse of the smoke of the cataract. Immediately after my arrival, I went with a friend to the northern end of the American Fall. It may be that my mood at the time toned down the impression produced by the first aspect of this grand cascade; but I felt nothing like disappointment, knowing, from old experience, that time and close acquaintanceship, the gradual interweaving of mind and Nature, must powerfully influence my final estimate of the scene. After dinner we crossed to Goat Island, and, turning to the right, reached the southern end of the American Fall. The river is here studded with small islands. Crossing a wooden bridge to Luna Island, and clasping a tree which grows near its edge, I looked long at the cataract, which here shoots down the precipice like an avalanche of foam. It grew in power and beauty as I gazed upon it. The channel, spanned by the wooden bridge, was deep, and the river there doubled over the edge of the precipice like the swell of a muscle, unbroken. The ledge here overhangs, the water being poured out far beyond the base of the precipice. A space, called the Cave of the Winds, is thus enclosed between the wall of rock and the cataract.

Goat Island terminates in a sheer dry precipice, which connects the American and the Horseshoe Falls. Midway between both is a wooden hut, the residence of the guide to the Cave of the Winds, and from the hut a winding staircase, called Biddle's Stair, descends to the base of the precipice. On the evening of my arrival I went down this stair, and wandered along the bottom of the cliff. One well-known factor in the formation and retreat of the cataract was immediately observed. A thick layer of limestone formed the upper portion of the cliff. This rested upon a bed of soft shale, which extended round the base of the cataract. The violent recoil of the water against this yielding substance crumbles it away, undermining the ledge above, which, unsupported, eventually breaks off, and produces the observed recession.

At the southern extremity of the Horseshoe is a promontory, formed by the doubling back of the gorge, excavated by the cataract, and into which it plunges. On the promontory stands a stone building, called the Terrapin Tower, the door of which had been nailed up because of the decay of the staircase within it. Through the kindness of Mr. Townsend, the superintendent of Goat Island, the door was opened for me. From this tower, at all hours of the day, and at some hours of the night, I watched and listened to the Horseshoe Fall. The river here is evidently much deeper than the American branch; and, instead of bursting into foam where it quits the ledge, it bends solidly over and falls in a continuous layer of the most vivid green. The tint is not uniform, but varied, long stripes of deeper hue alternating with bands of brighter color. Close to the ledge over which the water rolls, foam is generated, the light falling upon which, and flashing back from it, is sifted in its passage to and fro, and changed from white to emerald green. Heaps of superficial foam are also formed at intervals along the ledge, and immediately drawn down in long white striæ.[1] Lower down, the surface, shaken by the reaction from below, incessantly rustles into whiteness. The descent finally resolves itself into a rhythm, the water reaching the bottom of the fall in periodic gushes. Nor is the spray uniformly diffused through the air, but is wafted through it in successive veils of gauze-like texture. From all this it is evident that beauty is not absent from the Horseshoe Fall, but majesty is its chief attribute. The plunge of the water is not wild, but deliberate, vast, and fascinating. From the Terrapin Tower, the adjacent arm of the Horseshoe is seen projected against the opposite one, midway down; to the imagination, therefore, is left the picturing of the gulf into which the cataract plunges.

The delight which natural scenery produces in some minds is difficult to explain, and the conduct which it prompts can hardly be fairly criticised by those who have never experienced it. It seems to me a deduction from the completeness of the celebrated Thomas Young, that he was unable to appreciate natural scenery. "He had really," says Dean Peacock, "no taste for life in the country; he was one of those who thought that no one who was able to live in London would be content to live elsewhere." Well, Dr. Young, like Dr. Johnson, had a right to his delights; but I can understand a hesitation to accept them, high as they were, to the exclusion of

> "That o'erflowing joy which Nature yields
> To her true lovers."

To all who are of this mind, the strengthening of desire on my part to see and know Niagara Falls, as far as it is possible for them to be seen and known, will be intelligible.

[1] The direction of the wind, with reference to the course of a ship, may be inferred with accuracy from the foam-streaks on the surface of the sea.

On the first evening of my visit, I met, at the head of Biddle's Stair, the guide to the Cave of the Winds. He was in the prime of manhood—large, well built, firm and pleasant in mouth and eye. My interest in the scene stirred up his, and made him communicative. Turning to a photograph, he described, by reference to it, a feat which he had accomplished some time previously, and which had brought him almost under the green water of the Horseshoe Fall. "Can you lead me there to-morrow?" I asked. He eyed me inquiringly, weighing, perhaps, the chances of a man of light build and with gray in his whiskers in such an undertaking. "I wish," I added, "to see as much of the fall as can be seen, and where you lead I will endeavor to follow." His scrutiny relaxed into a smile, and he said, "Very well; I shall be ready for you to-morrow."

On the morrow, accordingly, I came. In the hut at the head of Biddle's Stair I stripped wholly, and redressed according to instructions—drawing on two pairs of woollen pantaloons, three woollen jackets, two pairs of socks, and a pair of felt shoes. Even if wet, my guide urged that the clothes would keep me from being chilled, and he was right. A suit and hood of yellow oil-cloth covered all. Most laudable precautions were taken by the young assistant of the guide to keep the water out, but his devices broke down immediately when severely tested.

We descended the stair; the handle of a pitchfork doing in my case the duty of an alpenstock. At the bottom my guide inquired whether we should go first to the Cave of the Winds, or to the Horseshoe, remarking that the latter would try us most. I decided to get the roughest done first, and he turned to the left over the stones. They were sharp and trying. The base of the first portion of the cataract is covered with huge bowlders, obviously the ruins of the limestone ledge above. The water does not distribute itself uniformly among these, but seeks for itself channels through which it pours torrentially. We passed some of these with wetted feet, but without difficulty. At length we came to the side of a more formidable current. My guide walked along its edge until he reached its least turbulent portion. Halting, he said, "This is our greatest difficulty; if we can cross here, we shall get far toward the Horseshoe."

He waded in. It evidently required all his strength to steady him. The water rose above his loins, and it foamed still higher. He had to search for footing, amid unseen bowlders, against which the torrent rose violently. He struggled and swayed, but he struggled successfully, and finally reached the shallower water at the other side. Stretching out his arm, he said to me, "Now come on." I looked down the torrent as it rushed to the river below, which was seething with the tumult of the cataract. De Saussure recommended the inspection of Alpine dangers with the view of making them familiar to the eye before they are encountered; and it is a wholesome custom, in places

of difficulty, to put the possibility of an accident clearly before the mind, and to decide beforehand what ought to be done should the accident occur. Thus wound up in the present instance, I entered the water. Even where it was not more than knee-deep its power was manifest. As it rose around me, I sought to split the torrent by presenting a side to it; but the insecurity of the footing enabled it to grasp the loins, twist me fairly round, and bring its impetus to bear upon the back. Further struggle was impossible; and, feeling my balance hopelessly gone, I turned, flung myself toward the bank I had just quitted, and was instantly swept into shallower water.

The oil-cloth covering was a great incumbrance; it had been made for a much stouter man, and, standing upright after my submersion, my legs occupied the centres of two bags of water. My guide exhorted me to try again. Prudence was at my elbow, whispering dissuasion; but, taking every thing into account, it appeared more immoral to retreat than to proceed. Instructed by the first misadventure, I once more entered the stream. Had the alpenstock been of iron it might have helped me; but, as it was, the tendency of the water to sweep it out of my hands rendered it worse than useless. I, however, clung to it by habit. Again the torrent rose, and again I wavered; but, by keeping the left hip well against it, I remained upright, and at length grasped the hand of my leader at the other side. He laughed pleasantly. The first victory was gained, and he enjoyed it. "No traveller," he said, "was ever here before." Soon afterward, by trusting to a piece of drift-wood which seemed firm, I was again taken off my feet, but was immediately caught by a protruding rock.

We clambered over the bowlders toward the thickest spray, which soon became so weighty as to cause us to stagger under its shock. For the most part nothing could be seen; we were in the midst of bewildering tumult, lashed by the water, which sounded at times like the cracking of innumerable whips. Underneath this was the deep, resonant roar of the cataract. I tried to shield my eyes with my hands, and look upward; but the defence was useless. My guide continued to move on, but at a certain place he halted, and desired me to take shelter in his lee and observe the cataract. The spray did not come so much from the upper ledge as from the rebound of the shattered water when it struck the bottom. Hence the eyes could be protected from the blinding shock of the spray, while the line of vision to the upper ledges remained to some extent clear. On looking upward over the guide's shoulder I could see the water bending over the ledge, while the Terrapin Tower loomed fitfully through the intermittent spray-gusts. We were right under the tower. A little farther on, the cataract, after its first plunge, hit a protuberance some way down, and flew from it in a prodigious burst of spray; through this we staggered. We rounded the promontory on which the Terrapin Tower stands, and pushed, amid the wildest commotion, along the arm of the Horseshoe,

until the bowlders failed us, and the cataract fell into the profound gorge of the Niagara River.

Here my guide sheltered me again, and desired me to look up; I did so, and could see, as before, the green gleam of the mighty curve sweeping over the upper ledge, and the fitful plunge of the water as the spray between us and it alternately gathered and disappeared. An eminent friend of mine often speaks to me of the mistake of those physicians who regard man's ailments as purely chemical, to be met by chemical remedies only. He contends for the psychological element of cure. By agreeable emotions, he says, nervous currents are liberated which stimulate blood, brain, and viscera. The influence rained from ladies' eyes enables my friend to thrive on dishes which would kill him if eaten alone. A sanative effect of the same order I experienced amid the spray and thunder of Niagara. Quickened by the emotions there aroused, the blood sped exultingly through the arteries, abolishing introspection, clearing the heart of all bitterness, and enabling one to think with tolerance, if not with tenderness, on the most relentless and unreasonable foe. Apart from its scientific value, and purely as a moral agent, the play, I submit, is worth the candle. My companion knew no more of me than that I enjoyed the wildness; but, as I bent in the shelter of his large frame, he said, "I should like to see you attempting to describe all this." He rightly thought it indescribable. The name of this gallant fellow was Thomas Conroy.

We returned, clambering at intervals up and down so as to catch glimpses of the most impressive portions of the cataract. We passed under ledges formed by tabular masses of limestone, and through some curious openings formed by the falling together of the summits of the rocks. At length we found ourselves beside our enemy of the morning. My guide halted for a minute or two, scanning the torrent thoughtfully. I said that, as a guide, he ought to have a rope in such a place; but he retorted that, as no traveller had ever thought of coming there, he did not see the necessity of keeping a rope. He waded in. The struggle to keep himself erect was evident enough; he swayed, but recovered himself again and again. At length he slipped, gave way, did as I had done, threw himself flat in the water toward the bank, and was swept into the shallows. Standing in the stream near its edge, he stretched his arm toward me. I retained the pitchfork handle, for it had been useful among the bowlders. By wading some way in, the staff could be made to reach him, and I proposed his seizing it. "If you are sure," he replied, "that, in case of giving way, you can maintain your grasp, then I will certainly hold you." I waded in, and stretched the staff to my companion. It was firmly grasped by both of us. Thus helped, though its onset was strong, I moved savely across the torrent. All danger ended here. We afterward roamed sociably among the torrents and bowlders below the Cave of the Winds. The rocks were covered with organic slime which

could not have been walked over with bare feet, but the felt shoes effectually prevented slipping. We reached the cave and entered it, first by a wooden way carried over the bowlders, and then along a narrow ledge to the point eaten deepest into the shale. When the wind is from the south, the falling water, I am told, can be seen tranquilly from this spot; but, when we were there, a blinding hurricane of spray was whirled against us. On the evening of the same day, I went behind the water on the Canada side, which, I confess, struck me, after the experience of the morning, as an imposture.

To complete my knowledge it was necessary to see the fall from the river below it, and long negotiations were necessary to secure the means of doing so. The only boat fit for the undertaking had been laid up for the winter; but this difficulty, through the kind intervention of Mr. Townsend, was overcome. The main one was, to secure oarsmen sufficiently strong and skilful to urge the boat where I wished it to be taken. The son of the owner of the boat, a finely-built young fellow, but only twenty, and therefore not sufficiently hardened, was willing to go; and up the river I was informed there lived another man who could do any thing with the boat which strength and daring could accomplish. He came. His figure and expression of face certainly indicated extraordinary firmness and power. On Tuesday, the 5th of November, we started, each of us being clad in oil-cloth. The elder oarsman at once assumed a tone of authority over his companion, and struck immediately in among the breakers below the American Fall. He hugged the cross freshets instead of striking out into the smoother water. I asked him why he did so, and he replied that they were directed *outward* not *downward*. At times, the struggle to prevent the bow of the boat from being turned by them was very severe.

The spray was in general blinding, but at times it disappeared, and yielded noble views of the fall. The edge of the cataract is crimped by indentations which exalt its beauty. Here and there, a little below the highest ledge, a secondary one jets out; the water strikes it, and bursts from it in huge, protuberant masses of foam and spray. We passed Goat Island, came to the Horseshoe, and worked for a time along the base of it, the bowlders over which Conroy and myself had scrambled a few days previously lying between us and the base. A rock was before us, concealed and revealed at intervals, as the waves passed over it. Our leader tried to get above this rock, first on the outside of it. The water, however, here was in violent motion. The men struggled fiercely, the elder one ringing out an incessant peal of command and exhortation to the younger. As we were just clearing the rock, the bow came obliquely to the surge; the boat was turned suddenly round, and shot with astonishing rapidity down the river. The men returned to the charge, now trying to get up between the

half-concealed rock and the bowlders to the left. But the torrent set in strongly through this channel. The tugging was quick and violent, but we made little way. At length seizing a rope, the principal oarsman made a desperate attempt to get upon one of the bowlders, hoping to be able to drag the boat through the channel; but it bumped so violently against the rock, that the man flung himself back, and relinquished the attempt.

We returned along the base of the American Fall, running in and out among the currents which rushed from it laterally into the river. Seen from below, the American Fall is certainly exquisitely beautiful, but it is a mere frill of adornment to its nobler neighbor the Horseshoe. At times we took to the river, from the centre of which the Horseshoe Fall appeared especially magnificent. A streak of cloud across the neck of Mont Blanc can double its apparent height, so here, the green summit of the cataract shining above the smoke of the spray appeared lifted to an extraordinary elevation. Had Hennepin and La Hontan seen the fall from this position, their estimates of the height would have been perfectly excusable.

From a point a little way below the American Fall, a ferry crosses the river in summer to the Canadian side. Below the ferry is a suspension bridge for carriages and foot-passengers, and a mile or two lower down is the railway suspension bridge. Between the ferry and the latter the river Niagara flows unruffled; but at the suspension bridge the bed steepens and the river quickens its motion. Lower down the gorge narrows, and the rapidity and turbulence increase. At the place called the "Whirlpool Rapids" I estimated the width of the river at 300 feet, an estimate confirmed by the dwellers on the spot. When it is remembered that the drainage of nearly half a continent is compressed into this space, the impetuosity of the river's escape through this gorge may be imagined. Had it not been for Mr. Bierstädt, the distinguished photographer of Niagara, I should have quitted the place without seeing these rapids; for this, and for his agreeable company to the spot, I have to thank him. From the edge of the cliff above the rapids, we descended, a little I confess to a climber's disgust, in an "elevator," because the effects are best seen from the water-level.

Two kinds of motion are here obviously active, a motion of translation, and a motion of undulation—the race of the river through its gorge, and the great waves generated by its collision with, and rebound from, the obstacles in its way. In the middle of the river the rush and tossing are most violent; at all events, the impetuous force of the individual waves is here most strikingly displayed. Vast pyramidal heaps leap incessantly from the river, some of them with such energy as to jerk their summits into the air, where they hang suspended as bundles of liquid spherules. The sun shone for a few min-

utes. At times, the wind, coming up the river, searched and sifted the spray, carrying away the lighter drops, and leaving the heavier ones behind. Wafted in the proper direction, rainbows appeared and disappeared fitfully in the lighter mist. In other directions the common gleam of the sunshine from the waves and their shattered crests was exquisitely beautiful. The complexity of the action was still further illustrated by the fact that in some cases, as if by the exercise of a local explosive force, the drops were shot radially from a particular centre, forming around it a kind of halo.

The first impression, and, indeed, the current explanation of these rapids is, that the central bed of the river is cumbered with large bowlders, and that the jostling, tossing, and wild leaping of the water there are due to its impact against these obstacles. This may be true to some extent, but there is another reason to be taken into account. Bowlders derived from the adjacent cliffs visibly cumber the *sides* of the river. Against these the water rises and sinks rhythmically but violently, large waves being thus produced. On the generation of each wave there is an immediate compounding of the wave-motion with the river-motion. The ridges, which in still water would proceed in circular curves round the centre of disturbance, cross the river obliquely, and the result is that, at the centre, waves commingle which have really been generated at the sides. In the first instance we had a composition of wave-motion with river-motion; here we have the coalescence of waves with waves. Where crest and furrow cross each other, the motion is annulled; where furrow and furrow cross, the river is ploughed to a greater depth; and, where crest and crest aid each other, we have that astonishing leap of the water which breaks the cohesion of the crests, and tosses them shattered into the air. From the water-level the cause of the action is not so easily seen; but from the summit of the cliff the lateral generation of the waves and their propagation to the centre are perfectly obvious. If this explanation be correct, the phenomena observed at the Whirlpool Rapids form one of the grandest illustrations of the principle of *interference*. The Nile "cataract," Mr. Huxley informs me, offers examples of the same action.

At some distance below the Whirlpool Rapids we have the celebrated whirlpool itself. Here the river makes a sudden bend to the northeast, forming nearly a right angle with its previous direction. The water strikes the concave bank with great force, and scoops it incessantly away. A vast basin has been thus formed, in which the sweep of the river prolongs itself in gyratory currents. Bodies and trees which have come over the falls are stated to circulate here for days without finding the outlet. From various points of the cliffs above, this is curiously hidden. The rush of the river into the whirlpool is obvious enough; and, though you imagine the outlet must be visible, if one existed, you cannot find it. Turning, however, round

the bend of the precipice to the northeast, the outlet comes into view.

The Niagara season had ended; the chatter of sight-seers had ceased, and the scene presented itself as one of holy seclusion and beauty. I went down to the river's edge, where the weird loneliness and loveliness seemed to increase. The basin is enclosed by high and almost precipitous banks—covered, when I was there, with russet woods. A kind of mystery attaches itself to gyrating water, due perhaps to the fact that we are to some extent ignorant of the direction of its force. It is said that at certain points of the whirlpool pine-trees are sucked down, to be ejected mysteriously elsewhere. The water is of the brightest emerald-green. The gorge through which it escapes is narrow, and the motion of the river swift though silent. The surface is steeply inclined, but it is perfectly unbroken. There are no lateral waves, no ripples with their breaking bubbles to raise a murmur; while the depth is here too great to allow the inequality of the bed to ruffle the surface. Nothing can be more beautiful than this sloping, liquid mirror formed by the Niagara in sliding from the whirlpool.

The green color is, I think, correctly accounted for in the "Hours of Exercise in the Alps." In crossing the Atlantic I had frequent opportunities of testing the explanation there given. Looked properly down upon, there are portions of the ocean to which we should hardly ascribe a trace of blue; at the most a hint of indigo reaches the eye. The water, indeed, is practically *black*, and this is an indication both of its depth and its freedom from mechanically-suspended matter. In small thicknesses water is sensibly transparent to all kinds of light; but, as the thickness increases, the rays of low refrangibility are first absorbed, and after them the other rays. Where, therefore, the water is very deep and very pure, *all* the colors are absorbed, and such water ought to appear black, as no light is sent from its interior to the eye. The approximation of the Atlantic Ocean to this condition is an indication of its extreme purity.

Throw a white pebble into such water; as it sinks it becomes greener and greener, and, before it disappears, it reaches a vivid blue-green. Break such a pebble into fragments, each of these will behave like the unbroken mass; grind the pebble to powder, every particle will yield its modicum of green; and, if the particles be so fine as to remain suspended in the water, the scattered light will be a uniform green. Hence the greenness of shoal water. You go to bed with the black Atlantic around you. You rise in the morning and find it a vivid green; and you correctly infer that you are crossing the bank of Newfoundland. Such water is found charged with fine matter in a state of mechanical suspension. The light from the bottom may sometimes come into play, but it is not necessary. A storm can render the

water muddy by rendering the particles too numerous and gross. Such a case occurred toward the close of my visit to Niagara. There had been rain and storm in the upper-lake regions, and the quantity of suspended matter brought down quite extinguished the fascinating green of the Horseshoe.

Nothing can be more superb than the green of the Atlantic waves when the circumstances are favorable to the exhibition of the color. As long as a wave remains unbroken, no color appears, but, when the foam just doubles over the crest like an Alpine snow-cornice, under the cornice we often see a display of the most exquisite green. It is metallic in its brilliancy. But the foam is necessary to its production. The foam is first illuminated, and it scatters the light in all directions; the light which passes through the higher portion of the wave alone reaches the eye, and gives to that portion its matchless color. The folding of the wave, producing, as it does, a series of longitudinal protuberances and furrows, which act like cylindrical lenses, introduces variations in the intensity of the light, and materially enhances its beauty.

We have now to consider the genesis and proximate destiny of the Falls of Niagara. We may open our way to this subject by a few preliminary remarks upon erosion. Time and intensity are the main factors of geologic change, and they are in a certain sense convertible. A feeble force, acting through long periods, and an intense force, acting through short ones, may produce, approximately, the same results. Here, for example, are some stones kindly lent to me by Dr. Hooker. The first examples of the kind were picked up by Mr. Hackworth on the shores of Lyell's Bay, near Wellington, in New Zealand, and described by Mr. Travers in the Transactions of the New Zealand Institute. Unacquainted with their origin, you would certainly ascribe their forms to human workmanship. They resemble flint knives and spear-heads, being apparently chiselled off into facets with as much attention to symmetry as if a tool guided by human intelligence had passed over them. But no human instrument has been brought to bear upon these stones. They have been wrought into their present shape by the wind-blown sand of Lyell's Bay. Two winds are dominant here, and they in succession urged the sand against opposite sides of the stone; every little particle of sand chipped away its infinitesimal bit of stone, and in the end sculptured these singular forms.[1]

[1] "These stones, which have a strong resemblance to works of human art, occur in great abundance, and of various sizes, from half an inch to several inches in length. A large number were exhibited, showing the various forms, which are those of wedges, knives, arrow-heads, etc., and all with sharp cutting edges.

"Mr. Travers explained that, notwithstanding their artificial appearance, these stones were formed by the cutting action of the wind-driven sand, as it passed to and fro over an exposed bowlder-bank. He gave a minute account of the manner in which the varie-

You know that the Sphinx of Egypt is nearly covered up by the sand of the desert. The neck of the Sphinx is partly cut across, not, as I am assured by Mr. Huxley, by ordinary weathering, but by the eroding action of the fine sand blown against it. In these cases Nature furnishes us with hints which may be taken advantage of in art; and this action of sand has been recently turned to extraordinary account in the United States. When in Boston, I was taken by Mr. Josiah Quincy to see the action of the *sand-blast*. A kind of hopper containing fine silicious sand was connected with a reservoir of compressed air, the pressure being variable at pleasure. The hopper ended in a long slit, from which the sand was blown. A plate of glass was placed beneath this slit, and caused to pass slowly under it; it came out perfectly depolished, with a bright opalescent glimmer, such as could only be produced by the most careful grinding. Every little particle of sand urged against the glass, having all its energy concentrated on the point of impact, formed there a little pit, the depolished surface consisting of innumerable hollows of this description. But this was not all. By protecting certain portions of the surface, and exposing others, figures and tracery of any required form could be etched upon the glass. The figures of open iron-work could be thus copied, while wire gauze placed over the glass produced a reticulated pattern. But it required no such resisting substance as iron to shelter the glass. The patterns of the finest lace could be thus reproduced, the delicate filaments of the lace itself offering a sufficient protection.

All these effects have been obtained with a simple model of the sand-blast devised for me by my assistant. A fraction of a minute suffices to etch upon glass a rich and beautiful lace pattern. Any yielding substance may be employed to protect the glass. By immediately diffusing the shock of the particle, such substances practically destroy the local erosive power. The hand can bear without inconvenience a sand-shower which would pulverize glass. Etchings executed on glass, with suitable kinds of ink, are accurately worked out by the sand-blast. In fact, within certain limits, the harder the surface, the greater is the concentration of the shock, and the more effectual is the erosion. It is not necessary that the sand should be the harder substance of the two; corundum, for example, is much harder than quartz; still, quartz-sand can not only depolish, but actually blow a hole through a plate of corundum. Nay, glass may be

ties of form are produced, and referred to the effect which the erosive action thus indicated would have on railway and other works executed on sandy tracts.

"Dr. Hector stated that, although, as a group, the specimens on the table could not well be mistaken for artificial productions, still the forms are so peculiar, and the edges, in a few of them, so perfect, that, if they were discovered associated with human works, there is no doubt that they would have been referred to the so-called 'stone period.'"—*Extracted from the Minutes of the Wellington Philosophical Society, February* 9, 1869.

depolished by the impact of fine shot; the lead in this case bruising the glass before it has time to flatten and turn its energy into heat.

And here, in passing, we may tie together one or two apparently unrelated facts. Supposing you turn on, at the lower part of this house, a cock which is fed by a pipe from a cistern at the top of the house, the column of water, from the cistern downward, is set in motion. By turning off the cock, this motion is stopped; and, when the turning off is very sudden, the pipe, if not strong, may be burst by the internal impact of the water. By distributing the turning of the cock over half a second of time, the shock and danger of rupture may be entirely avoided. We have here an example of the concentration of energy in *time*. The sand-blast illustrates the concentration of energy in *space*. The action of flint and steel is an illustration of the same principle. The heat required to generate the spark is intense, and the mechanical action, being moderate, must, to produce fire, be in the highest degree concentrated. This concentration is secured by the collision of hard substances. Calc-spar will not supply the place of flint, nor lead the place of steel, in the production of fire by collision. With the softer substances, the *total* heat produced may be greater than with the hard ones, but, to produce the spark, the heat must be intensely *localized*.

But we can go far beyond the mere depolishing of glass; indeed, I have already said that quartz-sand can wear a hole through corundum. This leads me to express my acknowledgments to General Tilghman,[1] who is the inventor of the sand-blast. To his spontaneous kindness I am indebted for these beautiful illustrations of his process. In this plate of glass you find a figure worked out to a depth of $\frac{3}{8}$ of an inch. Here is a second plate $\frac{1}{8}$ of an inch thick, entirely perforated. Here, again, is a circular plate of marble, nearly half an inch thick, through which open-work of the most intricate and elaborate description has been executed. It would probably take many days to perform this work by any ordinary process; with the sand-blast it was accomplished in an hour. So much for the strength of the blast; its delicacy is illustrated by this beautiful example of line-engraving, etched on glass by means of the blast.

This power of erosion, so strikingly displayed when sand is urged by air, will render you better able to conceive its action when urged by water. The erosive power of a river is vastly augmented by the solid matter carried along with it. Sand or pebbles caught in a river-

[1] The absorbent power, if I may use the phrase, exerted by the industrial arts in the United States, is forcibly illustrated by the rapid transfer of men like Mr. Tilghman from the life of the soldier to that of the civilian. General McClellan, now a civil engineer, whom I had the honor of frequently meeting in New York, is a most eminent example of the same kind. At the end of the war, indeed, a million and a half of men were thus drawn, in an astonishingly short time, from military to civil life. It is obvious that a nation with these tendencies can have no desire for war.

vortex can wear away the hardest rock; "pot-holes" and deep cylindrical shafts being thus produced. An extraordinary instance of this kind of erosion is to be seen in the Val Tournanche, above the village of this name. The gorge at Handeck has been thus cut out. Such water-falls were once frequent in the valleys of Switzerland; for hardly any valley is without one or more transverse barriers of resisting material, over which the river flowing through the valley once fell as a cataract. Near Pontresina, in the Engadine, there is such a case, the hard gneiss being now worn away to form a gorge through which the river from the Morteratsch Glacier rushes. The barrier of the Kirchet, above Meyringen, is also a case in point. Behind it was a lake, derived from the glacier of the Aar, and over the barrier the lake poured its excess of water. Here the rock, being limestone, was in great part dissolved, but, added to this, we had the action of the solid particles carried along by the water, each of which, as it struck the rock, chipped it away like the particles of the sand-blast. Thus, by solution and mechanical erosion, the great chasm of the Fensteraarschlucht was formed. It is demonstrable that the water which flows at the bottoms of such deep fissures once flowed at the level of what is now their edges, and tumbled down the lower faces of the barriers. Almost every valley in Switzerland furnishes examples of this kind; the untenable hypothesis of earthquakes, once so readily resorted to in accounting for these gorges, being now, for the most part, abandoned. To produce the cañons of Western America, no other cause is needed than the integration of effects individually infinitesimal.

And now we come to Niagara. Soon after Europeans had taken possession of the country, the conviction appears to have arisen that the deep channel of the river Niagara below the Falls had been excavated by the cataract. In Mr. Bakewell's "Introduction to Geology," the prevalence of this belief has been referred to: it is expressed thus by Prof. Joseph Henry in the Transactions of the Albany Institute: "In viewing the position of the Falls, and the features of the country round, it is impossible not to be impressed with the idea that this great natural race-way has been formed by the continued action of the irresistible Niagara, and that the Falls, beginning at Lewiston, have, in the course of ages, worn back the rocky strata to their present site."[1] The same view is advocated by Mr. Hall, by Sir Charles Lyell, by M. Agassiz, by Prof. Ramsay—indeed, by almost all of those who have inspected the place.

A connected image of the origin and progress of the fall is easily obtained. Walking northward from the village of Niagara Falls by the side of the river, we have, to our left, the deep and comparatively narrow gorge through which the Niagara flows. The bounding cliffs of this gorge are from 300 to 350 feet high. We reach the whirlpool, trend to the northeast, and, after a little time, gradually resume our

[1] Quoted by Bakewell.

northward course. Finally, at about seven miles from the present Falls, we come to the edge of a declivity which informs us that we have been hitherto walking on table-land. At some hundreds of feet below us is a comparatively level plain, which stretches to Lake Ontario. The declivity marks the end of the precipitous gorge of the Niagara. Here the river escapes from its steep, mural boundaries, and, in a widened bed, pursues its way to the lake, which finally receives its waters.

The fact that, in historic times, even within the memory of man, the fall has sensibly receded, prompts the question, How far has this recession gone? At what point did the ledge which thus continually creeps backward begin its retrograde course? To minds disciplined in such researches the answer has been, and will be, at the precipitous declivity which crossed the Niagara from Lewiston, on the American, to Queenstown, on the Canadian side. Over this transverse barrier the united affluents of all the upper lakes once poured their waters, and here the work of erosion began. The dam, moreover, was demonstrably of sufficient height to cause the river above it to submerge Goat Island; and this would perfectly account for the finding by Mr. Hall, Sir Charles Lyell, and others, in the sand and gravel of the island, the same fluviatile shells as are now found in the Niagara River higher up. It would also account for those deposits along the sides of the river, the discovery of which enabled Lyell, Hall, and Ramsay, to reduce to demonstration the popular belief that the Niagara once flowed through a shallow valley.

The physics of the problem of excavation, which I made clear to my mind before quitting Niagara, are revealed by a close inspection of the present Horseshoe Fall. Here we see evidently that the greatest weight of water bends over the very apex of the Horseshoe. In a passage in his excellent chapter on Niagara Falls, Mr. Hall alludes to this fact. Here we have the most copious and the most violent whirling of the shattered liquid; here the most powerful eddies recoil against the shale. From this portion of the fall, indeed, the spray sometimes rises, without solution of continuity, to the region of clouds, becoming gradually more attenuated, and passing finally through the condition of true cloud into invisible vapor, which is sometimes reprecipitated higher up. All the phenomena point distinctly to the centre of the river as the place of greatest mechanical energy, and from the centre the vigor of the fall gradually dies away toward the sides. The horseshoe form, with the concavity facing downward, is an obvious and necessary consequence of this action. Right along the middle of the river the apex of the curve pushes its way backward, cutting along the centre a deep and comparatively narrow groove, and draining the sides as it passes them.[1] Hence the remarkable discrepancy between the widths of the Niagara above and below the Horseshoe. All along

[1] In the discourse this action was illustrated by a model.

its course, from Lewiston Heights to its present position, the form of the fall was probably that of a horseshoe; for this is merely the expression of the greater depth, and consequently greater excavating power, of the centre of the river. The gorge, moreover, varies in width as the depth of the centre of the ancient river varied, being narrowest where that depth was greatest.

The vast comparative erosive energy of the Horseshoe Fall comes strikingly into view when it and the American Fall are compared together. The American branch of the upper river is cut at a right angle by the gorge of the Niagara. Here the Horseshoe Fall was the real excavator. It cut the rock, and formed the precipice over which the American Fall tumbles. But, since its formation, the erosive action of the American Fall has been almost *nil*, while the Horseshoe has cut its way for 500 yards across the end of Goat Island, and is now doubling back to excavate a channel parallel to the length of the island. This point, I have just learned, has not escaped the acute observation of Prof. Ramsay.[1] The river above the fall bends, and the Horseshoe immediately accommodates itself to the bending, following implicitly the direction of the deepest water in the upper stream. The flexibility of the gorge, if I may use the term, is determined by the flexibility of the river-channel above it. Were the Niagara above the fall far more sinuous than it is, the gorge would obediently follow its sinuosities. Once suggested, no doubt geographers will be able to point out many examples of this action. The Zambesi is thought to present a great difficulty to the erosion theory, because of the sinuosity of the chasm below the Victoria Falls. But, had the river been examined before the formation of this sinuous channel, the present zigzag course of the gorge below the fall could, I am persuaded, have been predicted, while the sounding of the present river would enable us to predict the course to be pursued by the erosion in the future.

But, not only has the Niagara River cut the gorge, it has carried away the chips of its own workshop. The shale being probably crumbled, is easily carried away. But at the base of the fall we find the huge bowlders already described, and by some means or other these are removed down the river. The ice which fills the gorge in winter, and which grapples with the bowlders, has been regarded as the transporting agent. Probably it is so to some extent. But erosion acts without ceasing on the abutting points of the bowlders, thus withdrawing their support, and urging them gradually down the river. Solution also does its portion of the work. That solid matter is carried down is proved by the difference of depth between the Niagara River and Lake Ontario, where the river enters it. The depth falls

[1] His words are: "Where the body of water is small in the American Fall, the edge has only receded a few yards (where most eroded) during the time that the Canadian Fall has receded from the north corner of Goat Island to the innermost curve of the Horseshoe Fall."—*Quarterly Journal of the Geological Society*, May, 1859.

from 72 feet to 20 feet, in consequence of the deposition of solid matter caused by the diminished motion of the river.[1]

In conclusion, we may say a word regarding the proximate future of Niagara. At the date of excavation assigned to it by Sir Charles Lyell, namely, a foot a year, five thousand years will carry the Horseshoe Fall far higher than Goat Island. As the gorge recedes, it will drain, as it has hitherto done, the banks right and left of it, thus leaving a nearly level terrace between Goat Island and the edge of the gorge. Higher up it will totally drain the American branch of the river, the channel of which in due time will become cultivable land. The American Fall will then be transformed into a dry precipice, forming a simple continuation of the cliffy boundary of the Niagara. At the place occupied by the fall at this moment we shall have the gorge enclosing a right angle, a second whirlpool being the consequence of this. To those who visit Niagara five millenniums hence, I leave the verification of this prediction; for my own part, I have a profound persuasion that it will prove literally true.

STATE GEOLOGICAL SURVEYS.

By Prof. ALBERT R. LEEDS,
of the Stevens Institute of Technology.

A STRENUOUS effort is being made at the present time to reorganize the Geological Survey of Pennsylvania. It promises to be successful. The legislators of that State, in voting upon the measure, will be mainly influenced by considerations relating to the pecuniary value of a geological survey in locating beds of coal, building-materials, and ores. But the educated public will desire to know, in addition to these matters, what influence such a geological survey will have upon the intellectual activity of the community at large, and how great an amount of scientific bustle it will create in the museums and laboratories of institutions of learning.

A very satisfactory answer can be given to the first of these queries, after reviewing the scientific periodicals and journals of learned societies in this country, during the last half-century. It will be seen that the desultory descriptions of plants, birds, and the external characters of minerals, which constituted a large portion of the scientific literature at the beginning of this period, gave place to laborious analyses, and to elaborate articles on geological phenomena. Many of the most valuable contributions to science during this epoch consisted in reports of the geological surveys then in progress, or in-

[1] Near the mouth of the gorge at Queenstown, the depth, according to the Admiralty Chart, is 180 feet; well within the gorge it is 132 feet.

vestigations connected with and growing out of them. Much of the best talent of the time was engaged upon these stupendous labors, and around the eminent chiefs were gathered bands of enterprising students, whose methods of scientific work were formed beneath the eyes of masters. The assistants of earlier surveys are the directors of those now in progress, and the crude sketches of former times are replaced by huge volumes filled with exhaustive details and magnificent generalizations.

Great as has been the work accomplished, the question may nevertheless be asked, whether the State geological surveys are, or have been, organized in such a manner as to exert the greatest possible influence upon the scientific progress of their respective States. As heretofore constituted, they have consisted of a director and a number of assistants, who have drawn their salaries and prosecuted their labors until the State appropriations have been exhausted. In some instances the work of the assistants has been appropriated by the director in such a manner that the geological survey has appeared to the public to be entirely represented in the person of its presiding officer. Granting that this officer is better qualified than any one else, it is evident, nevertheless, that a geological bureau, thus constituted, must reject a large part of the available talent of a State. Still worse, by taking possession of the field, and by closing the columns of the report to all but the paid officials of the survey, many whose labors might be of great value are rendered indifferent or hostile to the work. A bureau framed in the manner above described is proper enough in the survey of Territories still largely occupied by Indians, but it is by no means suited to the condition or needs of a densely-populated State. When a dozen flourishing colleges exist within the boundaries of a State, is it well that a general geological survey should be made in such a manner as to apportion little if any of its work specifically to them? A survey so constituted tends to encourage a disposition, unfortunately only too prevalent among our collegiate professors, to regard their entire duty as performed when the labor of teaching is accomplished. A few days ago an eminent civil engineer, who in his moments of *leisure* has collected one of the finest cabinets of minerals in this country and has made himself a practised mineralogist, complained that, after twenty years of disappointments, he had grown wearied of sending doubtful specimens to professors in colleges for determination, and of receiving no answers after the lapse of many months. As a final resort, he has determined new species himself, and had the chemical analysis performed by a hard-worked chemist in a manufacturing establishment. A large part of the work of a geological survey should be assigned to the colleges in a State, and should be voluntarily performed by their professors. Every State from Maine to Florida should be divided up into collegiate districts, the scientific development of which should be more immediately under the care of the particular

college in the midst of each. There is no reason why a system of joint effort, which from time immemorial has accomplished such wonderful things for religion and social order, should not be equally efficacious in scientific matters. A feeling of honorable pride should induce the officers and students of each institution to illustrate the flora and fauna, the mineralogy and geology of its collegiate district, more perfectly than any stranger could. The amount of intellectual labor which is utilized, and the number of valuable data collected each year, form but a small proportion of what is annually lost to the community through lack of organized effort. In a tersely-written letter to the Governor of Pennsylvania, urging the need of a new survey, Prof. Lesley says: "A most important function of a geological survey is, to *preserve* knowledge *for future use.* Science is cumulative. It makes slow and painful advances. It is obliged to collect an abundance of facts before it comes to true conclusions. Pennsylvania has lost enormously during the last twenty years by having no bureau of statistics, no corps of observation and publication, to observe and preserve, collate and relate, the facts of its geology and mineralogy, as they have successively made their appearance. No commonwealth can afford to be without such an apparatus for preserving from loss and forgetfulness the discoveries and investigations of private persons, even for one single year of its existence. Thousands of most valuable facts have been lost to us, during an interval, which cannot be recovered. How many openings on coal-veins are now covered up, no one being able to give any reliable information about them. Twenty thousand oil-borings have been made, and not one hundred of them are on record, if discoverable. Hundreds of gangways have been driven and abandoned, and cannot now be studied, many of which would disclose the nature of faults and disturbances which affect neighboring properties, and overlying and underlying beds not yet worked, where certain knowledge is preserved to govern the future mining-engineer in his plans for getting at the mineral. He must work as completely in the dark as if his knowledge had never been got, and often paid for at a ruinous expense. The sooner a geological survey is established, the better for the *future* interests of the State, as well as for its present necessities." At the height of the oil-fever in Pennsylvania, appreciating the wonderful opportunity which the sinking of innumerable wells afforded for obtaining complete geological sections of a vast area, I spent a long time in endeavoring to obtain from the superintendents engaged in boring, by personally visiting hundreds of wells in succession, the records of their work, and specimens of the penetrated strata. Printed circulars, asking for copies of such records in the interests of science, were sent to the secretary of every oil-company within our knowledge. Partly from the disgusting greed which possessed the oil-speculators to the exclusion of every higher feeling, and partly from an insane dread that the possession of such knowledge would be-

stow an infallible talisman for striking oil, these attempts were in but half a dozen instances successful. Is it wonderful that such crass ignorance should have entailed ruin upon thousands? Nothing but the publication of exhaustive geological reports, continued year after year, and printed both in full and summarized into short popular forms, can save the community at large from the repetition of similar follies. One single mining-fever costs the State more than all the appropriations needed to discover and universally diffuse the truths of geology. The ignorance spoken of above finds a parallel only in the methods which were pursued in treating the crude petroleum after it had been sent to market. The director of the principal chemical manufactory in Western Pennsylvania informed the writer that they first attempted to refine crude petroleum by throwing hundreds of pounds of bergamot and other perfumes into it, to *take away the smell.* If the reader says that this story is incredible, I can only repeat, "Yes, it is incredible."

It may be urged that few men are placed in such positions, or provided with such appliances, or possessed of sufficient leisure, to contribute any thing of value to the general stock of geological knowledge. But there are hundreds who would shrink from publishing a lengthy article or reading a paper before a learned body, and yet are acute reasoners and accurate observers, and whose abilities could be made available by a good system of collecting and collating their fragmentary labors. I have met many school-teachers and pastors in Switzerland whose parochial duties confined them to obscure valleys among the mountains, and who still had found time to collect the fossils, plants, and minerals, of their poverty-stricken hamlets, and to make careful maps of the rock-strata. They did so for two reasons: In the first place, the topographical map of General Dufour, on a scale of 1 to 100,000, previously accomplished by national aid, rendered it possible for them to locate their observations of strata, etc., with precision; and, secondly, because their contributions were utilized by the professors at Zurich, Bern, Geneva, and elsewhere, and incorporated in their published geological reports. A State survey, so organized as to make every intelligent school-teacher, every country-surveyor, every civil and mining engineer, chemist, amateur or collector, one of its working corps, would, we believe, do the work better, more cheaply, and with vastly more benefit to the material and intellectual prosperity of the State, than any present organization. This would be a school of science indeed, unincumbered by the dead weight of expensive school-buildings, whose laboratory and museum would cover every square foot of the State's surface.

NATURAL SELECTION IN POLITICS.

By Prof. D. H. WHEELER.

WHATEVER may become of Darwin's theory of natural selection, its worst foes must at last concede it the rare honor of being reckoned the most fertile hypothesis ever proclaimed. It has created a library of books on species, selection, and evolution, and it enters more or less into most attempts at serious writing. It was to be expected that it should turn up in politics; but we were hardly prepared for so brave an entry on that field as it makes in Bagehot's "Physics and Politics."

It is refreshing to know that Darwinism puts a more cheerful aspect upon physics in the social life of man than has been given to it by Draper and Buckle.

To Mr. Bagehot, the principle of natural selection applied to politics suggests the hopeful and beneficent side of law; Dr. Draper's books were preachments upon its awful and relentless aspects.

There is a valuable truth in natural selection applied to politics; for it is conceded that history shows us a struggle of races, and we who survive are ready enough to believe that the strongest survive because they are the best.

The earlier attempts to put physical forces into their place in man's social institutions, claimed a monopoly for them. The Gulf Stream wrote "Paradise Lost" and Newton's "Principia." The new attempt to trace these lines of law seems to promise success by leaving a little for Newton and Milton to do.

Physics work in harmony with morals. Morality is not a base and ragged accident, nor is it a fated product of temperature; it has relations to the weather, but the most important of these is its power to make, through industry and thought, a pleasant summer in an ice-bound city, and a grateful coolness in the torrid zone.

The moralists are fertile in all forms of social power; that is an old truth, too stubborn to be talked down. Religion has value everywhere, even in making fighters. God-fearing armies are hard to beat; and a man with an honest faith in him is as ugly a customer to face in fight as thirty degrees below zero. I hope nobody supposes that politics are without law. I know nothing so absurd as to believe in God and deny law to history, unless it be to be atheist and deny it. In truth, all of us shiver a little when we remember that God is just, or take account of the consequences that attend our public errors.

But the value of a truth is generally to be measured by its relation to hope. The best conquer, the best live; what an inspiration to courageous effort to be the best nation!

All the moralities, decencies, cultures, worships, lift up, and strength-

en, and vitalize a people; and the purer they are, the more they are worth as factors of nationality.

It is worth while to try to be decent, to reform bad habits, and fortify exposed places in our public life; for the best is the longest-lived.

This is not very new; a good deal of such preaching was wasted upon the Jews; but, after being sickened upon the doctrine that a fall of temperature produces a given number of suicides, and that morals have no influence in civilization, it is worth the cost of listening to a sermon, to get back again, under a disciple of Darwin, to the old truth, that it is well with the good, and ill with the evil, evermore on the earth.

The hopeful aspect given to *change* in national life by Darwinian Politics deserves special notice, and seems timely.

We are all afraid to change—born conservatives; and we all *want* something changed—born radicals; and we *do* change. All human life varies incessantly; the new generation sees life in new aspects, and rejoices in other colors. The variation comes in constantly; and it is our safety. Our inborn conservatism would kill us off if the variation did not help our inborn radicalism in the else unequal struggle. *That which is*, like the bird in the hand, is worth two reforms in the bush, for a contest. In short, nations grow, progress, thrive, through the law of variation from inheritance.

"One of the greatest pains to human nature is the pain of a new idea;" the consolation is, that only in pain does progress get birth, and that the things born are, on the whole, like the babies of any year, a little stronger and better than the things which die to give them room. Nor is this so because the moon is not made of green cheese, but because a beneficent law underlies human existence. The exceptions are numerous; so too are the small graves at Rose Hill, and yet there are more men on the earth, on the whole, happier than their ancestors, than there were fifty years ago. We must change; it is our cowardice or indolence that makes change a danger. The law deals generously with virtue and strength.

It is curious to mark how slowly we learn some of these simple lessons. A century ago, we respected, envied, the noble savage. The contemptible creature was semi-divine to first-rate poets and statesmen. They bewailed society, and longed for nakedness in the woods.

The same men knew that one Roman soldier had outmatched fifty semi-barbarians in every struggle, and that noble savages fell into the toils of the meanest civilized men in the slave-trade.

Civilization is strength and happiness. Miss Fragilla may not get all the new bonnets she wants; but that pain is easier borne than the "sound belashing" her ancestor got at her age, two centuries ago. She may not be all we could wish, but no young man of our blood would pass her by for a Choctaw princess.

The function of liberty in politics deeply interests us. Its power to promote healthful change is obvious. It is really liberty, with its discussion, its free thinking, and free speaking, that makes good politics. Cæsarism is a thief, robbing free times of their ideas and social results. It can live just as long as the loot holds out; but, when the stock on hand is exhausted, free men must be set to producing a new crop.—*The Northwestern Review.*

BARON LIEBIG.

JUSTUS VON LIEBIG, the famous German chemist, who died at Munich, April 18th, was born at Darmstadt, May 12, 1803. Having graduated from the gymnasium of his native place at the age of sixteen, his taste for the study of natural science led him first to accept a situation in an apothecary's shop, where he expected to have abundant opportunity for experiment and research.

After six months' service in the apothecary's shop, Liebig set out for the University of Bonn, where he studied for a while, and then went to Erlangen. At the latter university he attracted notice by the zeal with which he devoted himself to the study of chemistry, and he received from the Grand-duke of Hesse a "travelling stipend," which enabled him to spend two years (1822–'24) in Paris. There he had the advantage of association with Alexander von Humboldt, Gay-Lussac, and other eminent scientists. During his stay in Paris he read before the Academy of Sciences a paper on "Fulminic Acid" which at once stamped him as an able chemist. He was then only twenty-one years of age. In 1824 he was, through the influence of Humboldt, appointed Adjunct Professor of Chemistry in the University of Giessen, and two years later he succeeded to the full dignity of professor. The laboratory which he established at Giessen was the best-appointed school of chemistry in Germany, and thither flocked students from all parts of Europe, but especially from England, and also from this country. Leipsic and Göttingen set up chemical laboratories on Liebig's model, and the Giessen school became a kind of scientific focus, a centre of discovery, whose influence was felt everywhere.

Prof. Liebig visited England in 1838, attending a meeting of the British Association for the Advancement of Science. He there brought forward the discovery made by his associate, Wöhler, of a process for obtaining urea artificially. This announcement of the first successful step toward the synthesis of compounds in the laboratory, which had been supposed producible only under the influence of the mysterious forces of life, was received by the Association with profound interest. At the urgent request of the Association he wrote

his work on "Organic Chemistry, in its Application to Agriculture" (Brunswick, 1840), which was translated into most European languages, and had an enormous circulation both in Europe and America. In 1845 he received from his sovereign the honor of an hereditary barony. Seven years later, in 1852, he accepted the position of Professor of Chemistry in the University of Munich, and director of the chemical laboratory of that city.

His principal works, besides those already mentioned, are: "Animal Chemistry, or Chemistry in its Applications to Physiology and Pathology" (1842); and "Familiar Letters" (1844), which brought his views on applied chemistry before a very wide public, in a style so simple and popular that practical agriculturists could understand and profit by the instruction there conveyed.

In 1848 he commenced the publication of his "*Annalen*," or, "Annual Report of the Progress of Chemical Science." He published his "Researches on the Chemistry of Food" in 1849. His "Dictionary of Chemistry," in which he had the assistance of other writers, appeared in parts between 1837 and 1851.

In estimating the relation of Baron Liebig to the thought of his age, we are not to regard him as simply a chemist; he was much more —he was, in its broadest sense, a philosophical chemist, a man of ideas. Since the death of Berzelius, no man has appeared who had the weight of universal authority in chemical science. The subject has developed into such vastness of detail, that men can only become great by limiting themselves to special branches of it. Liebig devoted himself to organic chemistry, and even here there are other men who have probably surpassed him in the number and importance of their immediate contributions to the science. Yet, since Berzelius closed his career, no *savant* has appeared in the chemical field who has achieved so brilliant and conspicuous a position as Liebig.

He had in an eminent degree the traits of a successful pioneer in the world of thought. He was a man of impulse, sympathy, and enthusiasm, as well as of intellect. He could not give his life to simple, quiet laboratory investigation, content to make a few additions to the stock of scientific truth. Although trained to the strict methods of investigation, and competent to bend his energies to specific research, yet his manly interest in his fellow-beings, and the welfare and progress of society, determined the course of his studies, and led him constantly to the development of large practical results. When he began with organic chemistry, it was in its infancy, and chiefly confined to the production of a few organic compounds by laboratory decomposition. As for the chemical interpretation of the living organism, it was hardly thought of. The mystery of the vital forces reigned supreme, and barred the way to true inductive investigation. So also with agricultural chemistry. Davy had originated the name early in the century, and presented some of its elementary facts; but they did

not reach to practical results, and amounted to nothing in their influence upon the public. The work of Liebig was nothing less than to erect both these sciences into recognized branches of study, to direct the scientific thought of his age to these fields of inquiry, and to arouse the interest of the public in their practical applications; and this great work it is his lasting honor to have accomplished. That he should have committed errors, was inevitable. The first bold original speculations upon complex subjects cannot fail to be always imperfect. And, besides, that order of temperament which fitted him to be a reformer and a leader, and to stimulate and urge on other men, was favorable to rashness of generalization and a sanguine anticipation of conclusions. And yet Liebig's leading doctrines, to whatever degree requiring modification, were steps in the right direction of investigation; while their amendment and revision have made the reputations of other men.

Prof. Liebig's name will always be intimately and honorably associated with the rise of biological science in the nineteenth century. He stands at the beginning of one of the great epochs of knowledge, to which his genius has assisted to give development and direction, and he illustrates in an eminent degree that highest trait of modern character—devotion to scientific truth to the end of a large and noble utility.

It remains to be stated that Prof. Liebig entertained large and liberal political views. Although working under the European system with great success, ennobled by it, and appreciating its advantages, he nevertheless condemned its repressions and interferences, and looked beyond the ocean for the realization of his hopes and ideas. He was an enthusiast in regard to America, where he had many more readers than in any other country, and he expected great things from freedom, intelligence, and active enterprise in the United States. He even entertained serious notions of taking up his residence in our country. Like Agassiz, he saw that there were great possibilities for the future of science on this continent, and he indulged the idea, which was much more than a fancy, of establishing a great agricultural institution in one of the States. He would have been welcome here with a cordiality beyond his anticipation; for he was not only universally known and highly respected, but the most numerous class of the community—the agriculturists—recognized him as benefactor.

CORRESPONDENCE.

THE QUESTION OF COMPULSORY ATTENDANCE ON SCHOLASTIC EXERCISES IN COLLEGES.

To the Editor of the Popular Science Monthly:

THE press has recently occupied itself to an unusual degree with matters which concern our system of higher education; and a point on which the widest diversity of views has been expressed, and on which the argument on both sides has been maintained with the greatest ability and earnestness, is the question whether mental training is a process which can only be successfully conducted by assuming that its subjects will not in general receive it voluntarily, and whether, therefore, it is or is not necessary to proceed upon the plan of coercing them to their own good. This discussion originated in an intimation thrown out by President Eliot, of Harvard University, in his last annual report, to the effect that it might possibly be thought expedient in that institution hereafter to abolish the rules which make the attendance of students upon scholastic exercises compulsory, holding them, nevertheless, to rigorous examination upon the subjects taught, and conferring degrees in arts only upon satisfactory evidence of proficiency. This suggestion encountered a prompt and vigorous response and expostulation from the Rev. President McCosh, of Princeton, in a communication addressed, in January last, to the *New-York Evening Post*. Other writers took up the argument at greater or less length on both sides of the controversy; but nowhere has there appeared a more able or conclusive vindication of the wisdom of the principle involved in President Eliot's suggestion than that which was put forth in the March number of THE POPULAR SCIENCE MONTHLY. I cannot but thank you for your bold and free treatment of a subject in regard to which prescriptive usage, and the bias in the public mind which long prescription always carries with it, are against you; but which concerns in a very high degree the influence of our systems of education on the formation of the moral no less than the intellectual character of the youth who are subjected to it.

Immediately on the appearance of the article of Dr. McCosh, it was my design to offer a slight contribution to the literature of this subject, founded on my own personal observation of different educational methods during a thirty years' connection with the administration of colleges; but, owing to unforeseen interruptions, my labor remained unfinished on my hands until the favorable moment had passed by. My attention has been recently drawn to the subject again by the publication (also in the *Evening Post*) of a letter from Prof. Venable, Dean of the Faculty of the University of Virginia, describing the educational system of that institution, of which compulsory attendance is an essential feature, but referring in respectful terms to the plan proposed by President Eliot. This letter is presented by the *Post* as one of unusual importance and interest; yet it adds nothing to what has been universally known of the Virginia system for the past forty years, although it sets forth the leading features of this system with clearness and conciseness. In commending it, I understand the *Post* to be once more commending, though indirectly, the compulsory system; and this brings back to me my nearly-forgotten purpose above referred to, to have my word in this matter also.

I will commence, therefore, by remarking that all that Dr. McCosh has said, or that anybody may say, as to the importance of regular drill to the efficiency of any system of mental discipline, will be readily admitted by every experienced educator of youth. Whether, as that learned gentleman assumes, the undergraduate student is to be regarded as being too immature to be intrusted with a freedom which he may possibly abuse, or whether, with President Eliot, we suppose that he is as likely to attend to his collegiate exercises from a just appreciation of their value to himself, and a

proper sense of duty, as through any species of coercion, in either case there can be no doubt that this regularity of attendance is of indispensable importance, and that, in one way or another, it must be secured. It is supposed by Dr. McCosh that Harvard University may have been influenced in her views as to this subject by the presumed usages of foreign institutions of similar grade, or by the known practice of the professional schools of our own country; and, in regard to the colleges of Great Britain and Ireland, he hastens to correct the impression, if it exists, that attendance upon scholastic exercises is not made compulsory in them. It seems to me, nevertheless, to be unnecessary to go beyond the reason assigned by President Eliot himself as indicating the expediency of the change, in order to discover his motive for proposing it. This reason is, that the average age of the undergraduate students in Harvard University (and it may be added in all our colleges at present—at least in all those of the Atlantic States) is three or four years more advanced than it was in the earlier part of this century. Dr. McCosh admits the truth of this statement. He does not even seem to deprecate the fact that mature young men seek to avail themselves of the educational advantages which colleges offer. But he hardly attempts to disguise his conviction that the college was not designed for this class of students, nor that their actual predominance in it in numbers is evidence to him that it has been perverted from the original object of its institution. This is apparent from his remark that, "if there be a diminution in the number of young men attending colleges in relation to the population, it is very much owing to the circumstance that certain of the colleges have been practically raising the age of entrance, so as to prevent persons from entering upon their professional business until some of the best years of their life are spent." In his view, therefore, the existing state of things is an evil, and the blame of it is directly chargeable upon the colleges themselves. I do not, I confess, find the evidence to sustain this view of the case. The colleges have not raised the age of entrance by legislation. The minimum age in Columbia College is fifteen years. In Yale College it is fourteen, as it has been for the past half-century. In Harvard University there is no minimum at all. If there is any mode of "practically" raising the standard except by arbitrarily rejecting the younger class of applicants, notwithstanding that, by the published regulations, they are legally admissible, it does not occur to me to conjecture what it can be; yet this is not a practice which I have ever heard imputed to any American college. But it may be said that the colleges have brought the observed result to pass by increasing the severity of the entrance tests. This hypothesis can certainly not be sustained, so far, at least, as the classics are concerned (and it is here that the great labor of preparation lies), if we take as our guide the published entrance conditions. As a rule, the reverse is even the case, the amount exacted, measured by quantity if not by quality, being materially less than it was fifty years ago. Some little addition has been made to the amount of exaction in the mathematics, but not enough to make it difficult for a lad to prepare himself for college as early as fourteen, or earlier. To these statements, Harvard College may possibly present an exception, but the increased entrance exactions there have not been in operation long enough to have had any influence in producing the phenomenon in question. If it is a fact, therefore, that the average age of undergraduate students has risen—and I believe there can be no doubt about that—it is a fact which is not imputable to the colleges, nor one which they could control if they would; unless, indeed, instead of legislating about minimum ages, they should think proper to establish a *maximum* age, above which no applicant should be admitted, and should place this low enough to exclude every individual who has passed the years of boyhood. Such a measure would probably meet with few advocates. If it were important that we should explain the remarkable fact above mentioned, it would be quite sufficient to point to the immense improvement which has taken place within the century in the training-schools of grade inferior to the colleges—schools admirably and precisely fitted to the wants of boys of tender age, and armed with a coercive

power to hold them to their tasks tenfold as great as any college possesses, or can possess. For such striplings, it is well that they are at school, and that they are not in college; and to an intuitive perception of this truth on the part of parents it is unquestionably owing that so many remain there.

However this may be, we must take the facts as we find them, whether we would have them so or not, since it does not appear that we can very well make them other than they are. What is true in the present is likely to be permanently true in the future, viz., that the average age of undergraduate students in American colleges is, and will be, several years more advanced than it was three-quarters of a century ago, and even much more recently. And this important truth implies a very material change in the character of the student-body —a change marked by a large advance in maturity of judgment, an increased power of self-control, and a sensible diminution of the levity and volatility which distinguish the period of boyhood. To place such a community of young men under a system of restraints in nowise different from that which was originally devised for boys but a step removed from childhood, is to check the development of character in the direction of manly sentiment which should accompany this age, by tempting or compelling the student to govern his conduct not in accordance with the principles of propriety or right, but in obedience to an arbitrary, sometimes, in his judgment, an unreasonable, and often to his belief a needlessly oppressive rule.

The hope which President Eliot thinks it not unreasonable to entertain in regard to Harvard College, viz., "that it will soon get entirely rid of a certain school-boy spirit," which used to prevail there, but of which the traces are continually growing less, is a hope in which many similar institutions, with good reason, participate. It is a hope of which every judicious educator will do all that lies in his power to promote the fulfilment. The most unnecessary of the evils with which our colleges are at present afflicted are, those that grow out of such traces as still linger of this frivolous spirit. And if the rigorous rules which subject mature young men to a severe account of the disposition made of every moment of their time, or which place them under an irritating and annoying surveillance, are necessary (as it must be presumed they are supposed to be, or they would not be maintained), to assure their proper mental training, then certainly it is much to be lamented that these same necessary rules should be as prejudicial to their moral culture as they are said to be healthful to their mental. Is it not time, then, that we should begin to consider whether there are not influences capable of being brought to bear upon the undergraduate youth of our colleges, which will prove nearly, if not absolutely, as effectual in securing their regular attendance upon their scholastic exercises as any system of pains and penalties can be? Does the abandonment of the system of positive coercion involve necessarily the disastrous consequences apprehended by Dr. McCosh, of a neglect of faithful daily effort, and an attempt to satisfy the tests of proficiency imposed by the academic authorities, by means of a pernicious periodical cramming?

These are questions in regard to which no general agreement is likely to be reached by mere discussion. They are matters of opinion; and, when opinions differ in regard to what is likely to happen in hypothetical cases, it is generally true that the advocates of opposing views are more likely to be confirmed by argument in their original convictions, than converted to those of their adversaries. The only source from which, in matters of this kind, conclusions can be drawn which shall admit of no controversy, is actual experience; and thus far the results of experience have not been adduced by any of the parties to this discussion. President Eliot puts forward his proposed measure, not in the tone of confidence in which one speaks of a thing which has been tried and found to work well; but rather apparently as a feeler, for the purpose of trying the temper of the public mind, and ascertaining whether that is likely to tolerate so bold an experiment at Harvard; and Dr. McCosh trembles at the very thought of such an experiment in such an institution, being quite certain in advance that it must end in igno-

minious failure, and being apprehensive that the disastrous consequences which must follow will be felt in all the other colleges of the land. And yet, after all, this is not entirely a question of possibilities or probabilities. The experiment has been tried already, and tried until it is no longer an experiment. It has been tried at least long enough to prove that it is not surrounded by any of the dangers which seem so formidable to the distinguished president of Princeton, and that it is truly attended by all the advantageous consequences which are anticipated from it by the enlightened and progressive president of Harvard. This identical experiment has been tried for a period of more than four years in Columbia College; and it is this fact which has induced me to intrude the expression of my opinions into this discussion.

More than four years have now elapsed since the ordinary modes of compulsion, by which the attendance of students upon scholastic exercises is commonly enforced in colleges, were abandoned in this institution. As a substitute for these, the simple rule was adopted, that any marked irregularity of attendance on the daily exercises should debar the student from the privilege of attending the stated periodical examinations, through which every candidate for graduation is obliged by statute to pass, and to pass satisfactorily, before he can receive a degree in Arts. And, in order to remove any uncertainty which might exist as to the amount of irregularity which should be considered sufficient to deprive an individual of this privilege, the limit of tolerated absences from any particular department of study was put at one-fourth of the total number of exercises in that department. This limit was fixed upon, because it had been already tried, for several years, with results entirely satisfactory, in the School of Mines which is associated with the college, and which is carried on, on the same grounds. Under this system, a student may absent himself without being called upon to assign any reason for his absence. He may, if he pleases, assign such a reason voluntarily, or he may state in advance his desire or intention to be absent from a future exercise, and, in case he does this, a note is made of the reason so assigned, which is preserved for a purpose which will presently appear. In order that he may be always aware of the state of his absence account, a bulletin is kept constantly posted where it is accessible to him, exhibiting the number of his absences from every department separately, up to the current date. The data for this bulletin are derived from the daily reports of the college officers made to the president—each officer presenting his report for the day, immediately after the close of college hours—and from these the proper entries are made in the bulletin immediately. An abstract of this record is furnished monthly to the parent or guardian of every student; so that, if there be any unjustifiable irregularity, it is referred to the authority most suitable to investigate the causes and to apply the proper correction. If, at the close of the session, any student appears, from the record, to have exceeded his limit, in any department, he is notified that he is debarred from examination in that department; and the loss of an examination, in any single department, deprives him of his standing as a candidate for a degree. He is not on that account compelled to leave college. He may continue to attend as before; but, if, on account of growing irregularity, or inattention to study, his attendance should be deemed unprofitable to himself, or prejudicial to others, he may be required to withdraw. In this event, he retires silently, and without censure.

In case a student, whose absences for the session exceed the limit of tolerance, should be able to make it appear that all these absences were occasioned by causes beyond his control, or were otherwise justifiable, the faculty are at liberty, in their discretion, to raise the ban, and to admit him to examination. But, if *a single one* of these absences appears to have been wanton or unwarranted, it is of no avail to him that all the others were unavoidable—he loses his standing as a candidate for a degree.

Under this system an appeal is made to a higher motive than the fear of censure. It is inculcated on the student continually that to attend the college exercises is a privilege and a duty; to be absent a loss and a wrong to himself. And, when this idea becomes familiar, he will not only be-

come habituated to attend from choice, but he will profit more by his attendance, and will less frequently be found endeavoring to beguile the weary hours of his imprisonment in the class-room, by petty frivolities out of harmony with the character for manliness which he should at this period of his life be forming.

As to the results of this system in practice, the following remarks, taken from the annual report of the president of the college to the trustees, in 1869, which represent the facts as they apeared then, may be applied without any important modification to the experience of the more recent years: "The effects of the change have proved a very interesting subject of observation. After the lapse of four entire months, it may be said, of a large majority of the students, that no perceptible difference can be discovered at all in the degree of the regularity of their attendance upon scholastic exercises, as it was rendered before and after the adoption of the new regulations. A certain limited number have never been absent at all. A much larger number have been absent only at rare intervals. A number larger still, while absent more frequently, have not at all increased the frequency of their absences in consequence of the change of regulations. Some of these reside at inconvenient distances, or are liable to interruptions of their regularity from other causes beyond their control. . . . From an inspection of the record, it is safe to say that there are more than three-fourths of the entire college body, whose regularity of attendance has been totally unaffected by the introduction of the new regulations. In regard to the remaining fourth, or probably a proportion less than a fourth, it must be admitted that their irregularity of attendance has sensibly increased. This fact shows a degree of parental indifference or of parental indulgence which was hardly looked for; but the evil, so far as it exists, admits of a simple remedy, since the cause is obvious. The inspection of the record makes it quite evident that there is no necessity to make so large an allowance for occasional absences as one-fourth of the entire number. The majority of the students are probably not absent one-tenth of the number. It is practicable, and may be advisable, to reduce this latitude to one-sixth or one-eighth, or even to a less proportion, and the evil will inevitably disappear."

As yet, however, it has not been thought necessary to resort to the expedient here indicated; and, though, in the statutes of the college as they stand, the power is vested in the faculty to apply coercive measures to enforce attendance, this power has never been resorted to, nor has the evil increased. In occasional and very rare instances, a student has been obliged to withdraw from college on account of persistent irregularity or neglect of study; but this by no means more frequently than had been the case under the system of coercion. One quite effectual corrective, applied with us in cases of this kind, is, to require a student deficient in scholarship to study out of college hours under a private tutor, while still continuing his attendance with his classes; and to make his restoration to regular standing as a candidate for a degree dependent on the presentation of a certificate from his tutor, attesting his faithful attention to the studies prescribed, and his satisfactory proficiency in them.

The expedients here described, by which we aim to hold students in college to the proper discharge of their duties, may be said perhaps to partake, after all, of the nature of coercion; but they are not coercive in the sense in which that word is usually employed, when it implies a system of pains and penalties which offend a young man's self-respect, and carry with them, more or less, a sense of disgrace. If they are coercive, they are so precisely as the rules of morality or of gentlemanly propriety are coercive, by operating on the conscience; or as the suggestions of prudence in the ordinary affairs of life are coercive, by constraining men so to govern their conduct as not to prejudice their substantial interests. This is a kind of coercion under which we should desire all young men, and all men of every age, to be placed. It is in itself an educational influence, and one of the most salutary to which men can be subjected. When all our colleges shall have seen their way to the adoption of a regimen like this, as sooner or later they inevitably will, we may hope to see the complete disappear-

ence of that spirit of frivolity which too generally prevails at present among their inmates, and which President Eliot mentions to deprecate—a spirit already declining even in the absence of the healthful influence which the system I have attempted to describe brings with it, and which, though not yet wholly extinct, survives rather as a pernicious inheritance from other times, than because, in the conditions of modern educational institutions, it finds any thing properly congenial to its maintenance.

With one further remark I conclude. It is experimentally proved that no system of compulsory attendance in college is necessary to secure faithful attention to their duties and a conscientious improvement of their opportunities, on the part of that large proportion of undergraduate students whom collegiate education is likely to benefit. That smaller proportion, who will always neglect their duties if they can, will not greatly profit under any system, whether of absolute freedom, or of coercion, however rigorous. I am unable to perceive the wisdom of adapting systems of control with special, or, I may say, exclusive, reference to the case of those who least deserve to be considered, and out of whom the least is likely to be made; especially when this can only be done by depriving the rest of what seems to me to be one of the most felicitous moral influences which can surround and accompany them during the period of their education.

Very respectfully yours,

F. A. P. BARNARD.

COLUMBIA COLLEGE, *April* 2, 1873.

THE DANGERS AND SECURITIES OF SCIENCE.

To the Editor of the Popular Science Monthly.

MR. EDITOR: I listened, among others, to the speech of Mr. Parke Godwin at the Tyndall Dinner, and have been much interested both in the speech and in the discussions which have grown out of it. Of course, we cannot all expect to view the most important subjects in the same light, but I feel sure it is a mistake to attribute to Mr. Godwin any thing like a spirit of opposition or depreciation toward scientific progress or preëminence. On the contrary, what he said was, we believe, wholly in the interest of science. He simply gave expression, in unusually elegant and forcible language, to ideas which are entertained of late by many professionally scientific men. He did not propose to cramp scientific inquiry, nor to limit, in any way, its powers or its results, but only to prevent its contamination by what would degrade and cripple it. His speech, as we understand it, was a protest, not against science, but in its behalf, and against the damaging influence of pretended followers or mistaken friends.

There is no danger now that science can ever suffer from the attacks of its enemies, unless it be first debauched by the folly of its own partisans. Its progress for the last hundred years has been a series of triumphs, so numerous and brilliant that nothing else is now in a position to stand against it. And it owes this success entirely to the fidelity with which it has pursued its legitimate course, and the steady determination with which it has adhered to the method of strict scientific observation. For a long time we have given up the notion of the old philosophers, that men could discover things by thinking about them; and have only considered it worth while to spend our time in the investigation of actual phenomena. What has been, for the last half-century, the invariable demand of the world of science upon its votaries? Whenever any one made his appearance with a new claim to attention, the scientific public said to him, in effect: "What is that you have to tell us of this new body or substance? We do not wish to hear what you *think* about it, but only what you *know*. How much does it weigh? What are its form and structure? What are the actual results of its chemical analysis? What phenomena does it exhibit under special conditions? If it be a peculiar force or mode of activity, instead of a material substance, what are the exact conditions of its manifestation, and what are the results of its action, in quantity as well as in kind?"

This is the healthy and nutritious food upon which science has grown to her present proportions. In following such a track with such unswerving patience, she can

never make a mistake. But, the moment she leaves this path, she is in danger, or rather she is sure to go wrong, because whatever works by other than scientific methods is not science, and at best can only put on a kind of scientific garb, and masquerade in scientific phraseology.

Are there not some indications that we are not yet altogether beyond this danger? Are we not even more or less exposed to it at this particular time? Some scientific writers are certainly disposed to talk quite as much about their conclusions and theoretical explanations as about the phenomena they describe. There is no harm in this (except that it occupies a good deal of time that might be otherwise employed), provided they keep the boundary-line well marked between what they know and what they think on the subject in question. But they do not always do this. The hypothetical explanations are sometimes erected into a law, or principle, or theory, which, in the author's mind, evidently overshadows in importance every thing else. So we are sometimes supposed to have acquired a valuable piece of information when we are only, as the French say, "getting our pay in words." How much has been said and written for the past few years about *protoplasm!* Now, a student of physiology would be very excusable for thinking, from the manner in which this term is used, that protoplasm was some newly-discovered and important substance, with definite physical and chemical properties, and of the highest consequence in regard to vital organization. He would be considerably disappointed on finding it to be only a word representing a certain set of ideas, or at best a group of many various substances, each one of them specifically different from the rest.

There is even a certain kind of authority claimed, at least by implication, for some of these theoretical notions; and there is no doubt that they are occasionally assigned an established position as accepted truths, to which they are very far from being entitled. If it were not so improbable that Science could ever be induced to imitate in the least degree her old theological enemy, we might suspect even now a disposition in some minds to frame for us a sort of scientific Nicene Creed, the merit of believing in which would not depend exclusively upon the possession of sufficient reliable evidence. If such a creed were drawn up just at present, it would probably read something like this:

I BELIEVE in the Darwinian Theory;
In the Evolution Hypothesis;
In the Undulation of Light and the Luminiferous Ether; and
In the Atomic Constitution of Matter.

Now, we all know that theories are useful in their way, if confined within a very small compass, and employed only to stimulate rather than satisfy inquiry, and to suggest the direction in which new facts may be discovered. But, when they are raised to a higher dignity, and demand our belief in them as representing the actual constitution of Nature, then they are a misfortune to everybody concerned. If we treat them with any more respect than they deserve, we shall suffer for it inevitably by the loss of something which is infinitely more valuable than any of them. The records of the immediate past show the achievements which have been accomplished by means of strict adherence to exact methods of investigation. Should the scientific mind of to-day become ever so little intoxicated with its success, and undertake to decide questions which are beyond its horizon, it will certainly stultify itself, and lose the universal support and confidence which it has now so fairly acquired. For that reason I think that Mr. Godwin, in his Tyndall Dinner speech, was doing good service for science and scientific men, and that we are indebted to him for placing in a very distinct light the only source of danger for scientific interests in the future. J. C. D.

A CORRECTION.—LETTER FROM PROF. TYNDALL.

It is well known that many religious newspapers construed several of the speeches at the Tyndall banquet as righteous rebukes of the guest of the evening, on account of his irreligious science. His statement below was called out by a leading article in the *Christian Intelligencer* of February 13th, entitled "The Tyndall Banquet,"

from which the following is an extract: "A more significant farewell a visitor has never received at our hands. Prof. Tyndall was welcomed among us as a man of science. It was known, indeed, that he claimed, in that character, a warrant to question some popular religious faiths; but we may safely say that the professors of those faiths never supposed that he would carry his assumed warrant upon the platform and into his lectures on 'Light.' Yet he did that very thing, attacking, in those lectures, both our religious faith and one large class of its professors. Moreover, when the assaults thus made were formally complained of, he expressed no regret for them. Indeed, lest even so significant silence might fail to be appreciated, he now took pains to emboss upon his farewell speech the following remarkable sentences: 'Were there any lingering doubt as to my visit at the bottom of my mind; did I feel that I had blundered—and, with the best and purest intentions, I might, through an error of judgment, have blundered—so as to cause you discontent, I should now be wishing to abolish the doubt, or to repair the blunder; but there is no drawback of this kind.' After this unusual assertion of his perfect satisfaction with his course, it would have been unjust, both to him and to a very large part of his American audiences, to suffer him to depart without some weighty reminder of his mistake."

Of Dr. Hitchcock's address the writer remarks: "The few opening sentences which have thus far been printed indicate the dignified and manly tone in which American Christians resented, through him, the effort of one sort of science to disparage religion;" and he then says: "But Dr. Hitchcock did not stand alone. He had sympathizers enough among his hearers to indorse his expressions with repeated applause; and, what was even more significant, he found the heartiest support in the speech of Parke Godwin, who followed him, speaking for the press. The fact that a clergyman should vindicate the claims of religion, even at a dinner given in compliment to one of his assailants, might not seem in any way remarkable or important. But the editor of the *Post* had no professional zeal to rally him to the same battle; and when, after a detail of some of the most arrogant assumptions of irreligious scientists, he proceeded, with indignant eloquence, to remand their science to its own exact sphere, and to claim for revelation the settlement of the questions of 'primal origin and ultimate destinies,' Mr. Tyndall must have had a complacency quite impervious by ordinary weapons, if he persisted in thinking he had 'made no blunder,' and had 'caused no discontent.' Did Mr. Godwin suppose that the sentiments he was uttering were those of his guest? Did not he and all the company know they were not? Then, did he in uttering them, and they in applauding them, offer a gratuitous insult to the man they pretended to honor? No; but they did a loyal duty to the religion which he had wantonly assailed. They set a stint to their courtesy to the man, lest the excess of it should make a betrayal of their faith."

Upon which, Prof. Tyndall remarks as follows, in a letter to a friend:

"I confess to reading with some amazement the article on the 'Tyndall Banquet,' in the *Intelligencer*. I am there charged with attacking, in my lectures, both the Christian faith and one large class of its professors. If the telling of the truth be a necessary entry on the passport to 'the better land,' then, assuming the maker of this charge to be *not* in a state of invincible ignorance, I would not exchange my chances on the frontier of immortality for his. The fact is that, though solicited to do so, I steadily refused to quit the neutral ground of the intellect during my visit to the United States. My audiences in Boston, Philadelphia, Baltimore, Washington, Brooklyn, and New Haven, can testify whether a single word relating to religion was heard in any lecture of mine delivered in those cities. New York can answer whether, in five out of the six lectures there delivered, a syllable was uttered, *pro* or *con*, regarding religion. And I confidently appeal to that heroic audience which paid me the memorable compliment of coming to hear me on the inclement night when the words were spoken on which this charge is hung, whether, as regards its substance or its tone, what I then said could, with fairness, be construed into an attack 'upon religious faith, and one large class of its professors.' Put my

words and manner before them, and I would fearlessly trust to the manhood of any Young Men's Christian Association in the Union for a verdict in this matter. The writer in the *Intelligencer*, moreover, fails to see one conclusion to which his assertions inevitably lead; for, were they true, the perfectly unmistakable manner in which the 'attack' was received by the audience would prove the state of 'religious faith' in New York to be the reverse of creditable to him and others who have the care of it.

"The head and front of my offending hath this extent: At the conclusion of one of my lectures, I referred, for two minutes, in mild language, to the reported words—*reported, I would add, by a Presbyterian*—of the intemperate occupant of a single Presbyterian pulpit, and this is wilfully twisted by that occupant into an attack upon the Presbyterian body. The charge, as originally made, and as now echoed by the *Intelligencer*, is so silly that I did not think it worth public refutation. Why should I care about refuting it, when the sympathetic kindness of the very men I was reported to have assailed assured me that they did not believe a word of the indictment? I carried no more pleasant memory with me from the United States than that of my reception at the Presbyterian College of Yale. The high-minded youths and cultured gentlemen whom I met there, as indeed the Presbyterian body generally, a few hot-headed fanatics excepted, knew how to rate at its proper worth the statement of Dr. Hall, and they will, I am persuaded, assign to its echo in the *Intelligencer* the self-same arithmetical value.

"Should you deem this letter, or any part of it, necessary to public enlightenment, you are at liberty to make public use of it.

"Ever yours faithfully,

"JOHN TYNDALL."

EDITOR'S TABLE.

GEOLOGICAL SURVEYS IN THEIR EDUCATIONAL BEARINGS.

THE proposition of Prof. Leeds, in his article on "State Geological Surveys," to link these undertakings to the collegiate institutions of the country is a novel and very important one, and deserves the serious attention of all the friends of scientific education. After stating the aims and necessities of these surveys, the writer shows how college talent might be pressed into their service, and points out the advantages that would arise both in giving thoroughness to the work, and in diminishing its expense to the State. Prof. Leeds confines himself mainly to the consideration of economy, thoroughness in the performance of the work, and the interests of the survey itself. But such a measure could not fail to yield double advantages: it would be as good for the colleges as for the exploration. On educational grounds alone, nothing could be more desirable than to effect this arrangement, and give the colleges business of the kind contemplated.

A geological survey is but a systematic scientific inquiry into the structure and resources of a given region of country. It investigates the strata of the earth and their mineral and organic contents, both to find out how they are constituted, and to contribute useful productions to the arts and wants of society. In its full scope it inquires into the physical features of the region, its agricultural adaptations, its vegetable productions, its forms of animal life in earth, water, and air, its atmospheric conditions, salubrity, and general climatology. In short, it embraces a very full research into those facts of Nature which it is important for the community to know, and the business of science to determine. But the colleges have, for one great object, the teaching of those very things. A portion of their professors are devoted to it, of course under the assumption

that they are competent to carry it on.

Now, the result of such an alliance as is here proposed could not be other than salutary upon the institutions themselves. The effect of giving them a certain definite and responsible scientific work in their localities, the results of which would be brought to the test of public criticism, would inevitably be to elevate and sustain the standard of instruction in their laboratories and lecture-rooms. It is a grave difficulty with these higher institutions that their work cannot be brought to judgment and submitted to fixed and recognized tests. They are often the places for careless, slipshod, and aimless work. Mental results are not easy of inspection or valuation; sham and cram are showy and telling, and the constant temptation is to put them in the place of solid attainment; and, when college authorities can constantly fall back upon the pretext that their aim is *discipline*, and that knowledge is a quite subordinate matter, they open a door which allows any amount of loose and slovenly work, and at the same time permits the teachers to escape responsibility and criticism. But if a college were publicly placed in the scientific charge of the region in which it is situated, and required to make such reports thereof as could be accepted for guidance by the community, and brought into conspicuous comparison with similar work in other localities, the whole being under the supervision of able superintendents, a standard would be introduced that could not fail to give a high and authoritative tone to the work of the place.

But the effectual carrying out of the plan now proposed would not only insure able and qualified men as professors, but much more; it would call the students to the work, and secure the grand object of scientific education by bringing their minds into direct and systematic relation with natural phenomena. It would bring them out of their dormitories and class-rooms into the field, and, while favoring health and cultivating a sympathy with natural things, it would bring to bear the stimulus of curiosity and the love of search, while the intellectual work, being of the nature of independent observation and discovery, would be promotive of self-education—the best of all education. It is as notorious as it is deplorable that the scientific teaching of our colleges is grossly defective. Geology, botany, chemistry, physics, and zoology, are taught from books like Latin and history, with the aid, perhaps, of a few demonstrations by the lecturer. The information acquired is superficial and second-hand, and does not deserve the name of scientific knowledge. We believe the effect upon students of bringing them into close mental relation with surrounding Nature, of putting them in charge of a district, and requiring them to observe, classify, and describe its various objects, under the incitement that their useful work would have fair recognition, would be to give inspiration to study, solidity to acquirement, and the highest possibilities of usefulness to subsequent life.

An important consequence of such a plan would be, the growth of scientific museums which would represent the character and resources of the locality. As there is no educational appliance more important than a good museum, so there is no educational process more valuable than the formation of it. Those crude, miscellaneous, rubbishy collections of curiosities, and odd things gathered by accident, that are often thrown together, without method, in some unappropriated corner of an institution, are not entitled to the name of museums. Specimens are nothing except as illustrating ideas, and they require to be so arranged as to teach the science to which they belong. As we ordinarily find them, museums are hardly more instructive than so much blank space. A

good local collection should represent, in its specimens, the zoology, botany, and geology of the district. It should be arranged with a view to teaching, and, instead of being crowded with a multiplicity of objects, should consist of carefully-selected, well-arranged, and clearly-labelled *types* of the classes, orders, families, and leading genera of animals and plants, extant in the region, and gathered in their fossil vestiges, from its geological formations, which are at the same time represented by classified minerals.

The plan now suggested, by which it would become the official duty of college authorities to bring together the products of a region, so that they would be accessible to everybody in quest of this kind of information, and at the same time tributary to the purposes of science, would give us museums worthy of the name, and secure the proper objects of their establishment.

In every aspect, therefore, the project of establishing so close a connection between State geological explorations and our higher educational institutions is to be cordially commended; and it is not the least of its advantages that it coincides with the great tendencies of educational reform, and offers an efficient method of carrying it forward.

SCIENTIFIC THEORIZING.

In our correspondence for this month will be found a letter from a distinguished American physiologist, approving the position taken by Mr. Godwin in his speech at the Tyndall dinner, as "a protest, not against science, but in its behalf, and against the damaging influence of pretended followers or mistaken friends;" and this view expresses, we are assured, the conviction of many professionally scientific men of the present time.

We have no desire to prolong controversy, but, with all respect to the professional authorities, we must continue to think that the efforts to limit and confine scientific investigation in the present age are not in the interest of true science; nor can we see how they differ from attempts to obstruct the advance of thought that have been made in preceding ages. There has always been a party unwilling to allow science to find its own limits. They have forbidden each step of its progress, and demanded that it should keep within its sphere, for the sake of its own good. They have never denied science, or questioned its authority, but only demanded that it should consult its own interests by staying in its proper place. When the work of investigating Nature was seriously commenced, some three or four centuries ago, "Aristotle," "Galen," and "Mathematics," were terms used to define the scope of legitimate science; and, when the first great step forward was taken, and men began to question the tradition of the flatness of the earth, they were sharply met with the charge that they were going beyond their sphere and damaging science itself. Men were as free as the wind to pursue true science—that is, to accept Aristotelian and Galenic dicta, and to cultivate the whole range of mathematics. The ideal world was a sphere of exact and eternal truth; external Nature was a mere flux of sensuous appearances, not suspected to be a sphere of law; the attempt to study her was therefore to invade the ancient and inviolable limits of science. Hence, in denying the flatness of the earth, and affirming its sphericity, the early inquirers not only shocked commonsense but were charged with violating every canon of established scientific method. Exactly the same considerations that are now urged were urged then with tenfold force, and the antagonists of the new doctrine might well have said that they "did not propose to cramp scientific inquiry,

nor to limit in any way its powers or its results, but only to prevent its contamination by what would degrade and cripple it." And these tactics have been repeated at every great step of advancement. It is never genuine science that breaks over the old limits of opinion, but always "pretended science," "pseudo-science," and "science falsely so called."

In our correspondent's opinion, science has now attained a position in which it holds its destiny in its own hands, and is in no danger save from the folly of its own partisans. His theory of the case is, that science is now endangered by excess of theory. But, if that be the case, it is threatened by its own breath of life. A theory is only a view taken by the mind in its effort at explanation, and cannot be dispensed with, if observation and experiment are to be put to their true use. He says that science demands of its votary, "not what you *think* about it, but what you *know*." But what is knowing but thinking brought to the highest certainty? and how can this end be reached except by the successive steps of conjecture and hypothesis? As Dr. Whewell observes, "To try wrong guesses is apparently the only way to hit upon right ones." It is not Science which puts an embargo upon thinking and theorizing, for it is by these that all her laws have been arrived at. Of course, science demands certainty, demonstration, and experimental exactitude, if obtainable; and if not, then the nearest approach to them possible; but these must have an ideal and a meaning, or there can be no science. Science is not manipulation, but the thinking that accompanies it, and the theory or view that is established by it. Under the rigid rule laid down by the writer, the giant intellects who have made the epochs of science could never have got a hearing. Copernicus, Galileo, Columbus, Newton, Harvey, Dufay, Young, and Dalton, are known to the world as *thinkers*, and have gained immortality in science, and guided the multitude of lesser men by their *theories*. Faraday remarks that the world little knows how many conjectures and hypotheses, which arise in the minds of philosophers, are crushed by the severity of their own adverse criticism; but the world does know something of the number of theories that are submitted to the tribunal of science, and are crushed by the adverse criticism there encountered. Are these efforts of theory, therefore, in either case, to be interdicted or discouraged? Our correspondent has little patience with theories, but they are the measure of mental activity and the essential form of its scientific expression, as their inexorable testing is the measure of sound scientific method. There may be peril in theorizing, as there is in steam, but it is the condition of getting on; and, because brakes are useful, let us not put out the fires.

If there is more theorizing now than ever before, it is because there is far more extensive scientific activity. There is, indeed, greater demand for it now than ever, for the numbers of observers and experimenters who either cannot think or are afraid to think have greatly multiplied in recent years, increasing the mass of observations and fragmentary results, which can only be organized into accepted theory by the highest order of minds. Generalizations and inductions which bind up isolated facts in manageable form, and which constitute the very texture of science, are only to be arrived at by thinking and theorizing. And with the multitude of men thoroughly trained in all departments, and sharpened to the work of criticism, there is certainly less danger now than ever that worthless theories should gain the ascendency.

The hypothesis, that in future science can suffer no damage save from enemies in its own household, we ven-

ture to think, represents but a small portion of the pertinent facts. Much has undoubtedly been gained by past conflict; astronomers are no longer imprisoned, and physiologists no longer roasted. But have ignorance and intolerance been banished from the world? or, remaining in it, have they lost their aggressiveness or their influence over men's minds? Have they, in fact, done more than change weapons? We grant that the antagonism to science has greatly diminished within recent years; but, to say that science has now to encounter no external adverse influences which affect its prosperity, is to talk at random. The world is still dominated by illiberality and prejudice; and when science puts forth ideas that do not square with prevailing belief, as, from its progressive nature, it has always been doing, and must continue to do, it is met with anger and denunciation, which it requires no little moral courage to withstand. It cannot reasonably be claimed that such a state of things is without influence upon scientific interests. It represses the honest and healthy expression of opinion; it checks young men from entering the scientific field; it resists scientific education; and it hinders men of science from obtaining the necessary means for prosecuting their inquiries.

Even our correspondent puts Science upon its good behavior before a censorious world. He affirms that she may incur damage, and is exposed to danger from her enemies, but these evils, it is alleged, can only come from "contamination" and "debauchery" by her own partisans. And what is meant by this language, but the promulgation of doctrines that her enemies regard as odious? Stop a hundred men in the street, and ask them what they consider to be the great contamination and debauchery of science at the present time, and ninety-nine of them will reply, "Darwinism"—the first item in our correspondent's new "Nicene Creed." This is the verdict of public opinion. But we open the new volume of Helmholtz, who is probably the most eminent and authoritative scientist in Europe, and, in his lecture on the "Aims and Progress of Physical Science," we read that "Darwin's theory contains an essentially new creative thought." This is the verdict of science. Is the great German one who brings discredit upon his class by thinking instead of knowing? and is the party which characterizes the creative conceptions of Nature as degradations, to be accepted as the arbiter of the proper limits of science? We remain of opinion that scientific men are the best judges of the legitimacy of their own inquiries, and that they will honor themselves most by the bold and fearless prosecution of these inquiries, let them lead wherever they may.

TO THE PUBLIC.

A book entitled "Youman's Dictionary of Every-Day Wants" is being extensively circulated by canvassers, and I am much annoyed at finding that it is purchased under the impression that it is by the Editor of The Popular Science Monthly, and the author of the "Hand-Book of Household Science," "Chemistry," etc. I am neither the author of it, nor have I had any thing to do with its preparation; and, in so far as my name has been used to sell it, it is a fraud. It will be an act of justice to the public, as well as to myself, if the press will kindly reproduce this card. E. L. Youmans.

LITERARY NOTICES.

Lessons in Elementary Anatomy. By St. George Mivart, F. R. S., etc. Macmillan & Co., London and New York, 1873.

This is a companion volume to Huxley's "Lessons in Physiology" and Oliver's "Lessons in Botany," and is devoted mainly to a description of the human body, with

only so much of the anatomy of the lower animals as will serve to illustrate the variations which corresponding organs exhibit in the inferior vertebrates. The first chapter begins with a general survey of the structure of the human body. This is followed by a brief account of the classification of animals, in which the author, adopting the more modern views, names seven sub-kingdoms, illustrating each with the figure of some typical form. The characters, more or less common to all animals, man included, are next pointed out, when leave is taken of the invertebrates, and a consideration of the principal subdivisions of the group or sub-kingdom to which man belongs closes the chapter. The six succeeding chapters, or lessons, taking up in all 218 pages of the book, are upon the skeleton, wherein the various systems of bones are treated, each being described, first, as it is developed in man, and then as it appears in homologous parts of other vertebrates. The reasons given by the author for allotting so much space to this dry subject are: "1. The general resemblance borne by the skeleton to the external form. 2. The close connection between the arrangement of the skeleton and that of the nervous system, muscles, and vessels. 3. The relations borne by the skeleton of each animal to the actions it performs, i. e., to the mode of life and habits of the various animals. 4. The obvious utility of the skeleton in classification and the interpretation of affinity. 5. Parts of the skeleton or casts of such are all we possess of a vast number of animals formerly existing in the world, but now entirely extinct; a good knowledge of the skeleton must, therefore, be of great utility to those interested in palæontology." Lesson eight, occupying the next 64 pages, is on the muscles, which are dealt with in the same manner as the bones—that is, they are first described as they exist in man, the more important deviations from this type in other vertebrate animals being afterward pointed out. The same method is pursued in the four remaining lessons, which are on the nervous, circulatory, alimentary, and excretory systems, respectively.

The book closes with a tabulated summary, first, of the characters which distinguish man from the animals belonging to the four lower classes of the vertebrate sub-kingdom; and, second, of the characters which separate him from all other mammals. The volume is clearly printed, has a very full index, and, on the whole, seems well suited to the use of teachers and others who already know something of the subject. But for beginners we doubt its utility, as it is altogether too technical to be attractive to them, and too closely written to be readily grasped by minds unfamiliar with this class of subjects.

ANTIQUITIES OF THE SOUTHERN INDIANS, PARTICULARLY OF THE GEORGIA TRIBES. By CHARLES C. JONES, JR. New York: D. Appleton & Co., 1873.

THIS work is devoted to a consideration of the monuments, relics, and ancient customs of the aboriginal population formerly inhabiting that portion of the United States which is now comprised within the limits of Virginia, the Carolinas, Georgia, Florida, Alabama, Mississippi, Louisiana, and Tennessee. The antiquities of Georgia receive special attention, for with them the author is most familiar. But, as all the tribes occupying the territories indicated above had almost identical customs and arts, what applies to one section will apply to all, as the author well shows. We think, however, that he ought to have made an exception of the Natchez, who were sun-worshippers, and, in virtue of that higher grade of fetichistic religion, raised considerably above the neighboring tribes. But the author has no ambition to philosophize about the religious or *cultural* status of the extinct peoples whose memorials he has exhumed. He simply narrates what he has seen, citing here and there the notes of ancient and modern travellers to show the purpose of an artificial mound, or moat, or plateau, or the meaning of an outlandish ceremony, etc.

The first three or four chapters of the work give an account of the *habitat*, the physical characteristics, manners and customs, and arts of the Southern Indians, at the period when first they came in contact with men of European race, and particular attention is bestowed upon their costume, manufactures, ornaments, games, festivals, marital relations, forms of government, re-

ligious ideas, and funeral customs. The remainder of the book, and its larger portion, classifies and describes very fully the various monuments of early constructive skill, implements, utensils, ornaments, and manufactures of these primitive tribes.

The illustrations consist of 31 plates and several woodcuts of objects mostly in the author's private collection, which are here figured for the first time.

THE CHILDHOOD OF THE WORLD. By EDWARD CLODD. London and New York: Macmillan, 1873.

THIS is, we believe, the first book of its kind that has ever been published, at least in English—a primer of anthropology and archæology, giving the results of advanced modern science, and intended for the instruction of young children. It is written in attractive style, and is sure to gratify the young folk. The author contrives to convey a very large amount of information in very small space and in very simple language; he can simplify without debasing, and can instruct the young, without ever resorting to unworthy tricks or making drafts on their credulity, which maturer years would lead them to discount. The paper, print, and binding of the book, are all that could be desired.

THE MECHANISM OF THE OSSICLES OF THE EAR AND MEMBRANA TYMPANI. By H. HELMHOLTZ. Translated from the German, with the author's permission, by ALBERT G. BUCK and NORMAND SMITH. New York: Wm. Wood and Co., 1873.

IN this little work Dr. Helmholtz comes before the world bringing the results of his own observation, and, as a matter of course, he pours a flood of light upon the subject which he treats. The essay is intended for professional men, and for students familiar with physiological science, and both these classes of readers will find here the only treatise in any language which discusses fully the anatomical, physiological, and mathematical aspects of the matter in hand.

BOOKS RECEIVED.

Logic of Medicine. By Edward S. Dunster, M. D. New York: D. Appleton & Co. 1873.

The Criminal Use of Proprietary and Advertised Nostrums. By Ely Van de Warker, M. D. New York: D. Appleton & Co., 1873.

The Short-Footed Ungulata of the Eocene of Wyoming. By Edward D. Cope.

Criminal Responsibility of Epileptics. By M. G. Echeverria, M. D.

New Method of preserving Tumors, etc., during Transportation. By Joseph G. Richardson, M. D. Philadelphia: Lippincott, 1873.

Mechanism of the Ossicles of the Ear and Membrana Tympani. By H. Helmholtz. New York: William Wood & Co., 1873.

The Scientific Bases of Faith. By Joseph John Murphy, Author of "Habit and Intelligence." London and New York: Macmillan, 1873.

The Unity of Law; as exhibited in the Relations of Physical, Social, Mental, and Moral Science. By H. C. Carey. Philadelphia: Henry C. Baird, 1873.

The Romance of Astronomy. By H. Kalley Miller, M. A. London and New York: Macmillan, 1873.

The Childhood of the World; a Simple Account of Man in Early Times. By Edward Clodd, F. R. A. S. London and New York: Macmillan, 1873.

The Sanitarian. A Monthly Journal. A. N. Bell, M. D., Editor. New York: A. S. Barnes & Co., 1873. $3.00 *per annum.*

Prayer and the Prayer-Gauge. By Rev. Mark Hopkins, D. D. Albany: Weed, Parsons & Co., 1873.

The Upper Coal-Measures west of the Alleghany Mountains. By John J. Stevenson. Salem, Mass., 1873.

MISCELLANY.

Action of Drought and Cold on Forest-Trees.—In an able paper on the manner in which the distribution of plants and animals may be influenced by extraordinary changes in the character of the seasons, published in the *American Naturalist* for November last, Prof. N. S. Shaler attributes the wide-spread destruction of evergreen

trees, which became so painfully apparent during the previous spring, to the action of drought and cold. The year preceding was, in New England, one of the dryest on record, the ground, when winter set in, holding a comparatively small amount of moisture. This left the roots of trees deficient in sap. Not being well protected by snow, the ground in winter was frozen to a great depth, and, as the frost left the roots in spring, they remained for some time in contact with relatively dry earth, thus causing a shock too great for their vitality to withstand. During the succeeding summer Prof. Shaler also observed a remarkable scarcity of snakes and toads, which he is likewise inclined to ascribe to the great severity of the previous winter. Concerning the effect of such climatic accidents on the character of our forests, he says:

"Small as the destruction of forest-trees is, it will doubtless add several per cent. to the deciduous trees of New England, and remove an equal amount of conifers. The conifers seem to be relics of an old time, and not competent to wage a successful war with their younger and more elastic competitors, the oaks, beeches, and other deciduous trees. Every gap that is made in our forests of cone-bearing species is filled not with their legitimate successors, but by forms from the other class of trees. Let us suppose that the shock of the last season had been great enough to kill off the whole of our pines, the result would have been a complete change in the character of our forests; oaks generally would take the vacant place. This would affect the character of the undergrowth very materially, for the lesser plants of a pine-wood are very different from those which flourish beneath oaks. This would have had a very great effect upon insect-life, and more or less directly influenced the number and character of the birds and the mammals. Even the climate would be in some small measure influenced, for a pine-forest retains the snow better than one which loses its leaves in the winter, and thus tends to secure a more equable temperature in the region where it lies. Thus we see that an accidental drought might bring about a change in the assemblage of vital conditions on the surface of the land, as great as those which, when recorded in strata, we accept as indicating distinct geological formations."

Dental Art among the Japanese.—Dr. W. St. George Elliott, formerly of this city, now at Yokohama, Japan, sends to the *Dental Cosmos* an interesting account of Japanese habits in regard to teeth, and of the state of dentistry in that empire. He says that the teeth of the daughters of Japan are objects of envy, and it is remarkable that a nation who place so much value upon their teeth should keep up the custom of blacking them after marriage. As a race the Japanese have not good teeth, and it is rare to find an old person with any at all. Their tooth-brushes consist of tough wood, pounded at one end to loosen the fibres. They resemble paint-brushes, and owing to their shape it is impossible to get one behind the teeth. As might be expected, there is an accumulation of tartar which frequently draws the teeth of old people. The greatest accumulation is behind the lower orals, and these are frequently cemented together by a dense, dark-brown deposit, a quarter of an inch in thickness. Their process of manufacturing false teeth is very crude. The plates are made of wood, and the teeth consist of tacks driven up from the under side. A piece of wax is heated, and pressed into the shape of the roof of the mouth. It is then taken out and hardened by putting it into cold water. Another piece of heated wax is applied to the impression, and, after being pressed into shape, is hardened. A piece of wood is then roughly cut into the desired form, and the model, having been smeared with red paint, is applied to it. Where they touch each other a mark is left by the paint. This is cut away until they touch evenly all over. Shark's-teeth, bits of ivory, or stone, for teeth, are set into the wood and retained in position by being strung on a thread which is secured at each end by a peg driven into the hole where the thread makes its exit from the base. Iron or copper tacks are driven into the ridge to serve for masticating purposes, the unequal wear of the wood and metal keeping up the desired roughness. Their full sets answer admirably for the mastication of food, but, as they do not improve the looks, they are worn

but little for ornament. The ordinary service of a set of teeth is about five years, but they frequently last much longer. All full upper sets are retained by atmospheric pressure. This principle is coeval with the art. In Japan, dentistry exists only as a mechanical trade, and the status of those who practice it is not very high. It is, in fact, graded with the carpenters—their word *hadyikfsan* meaning *tooth-carpenter.*

Vegetable Ivory.—The kernel of the corrozzo-nut so closely resembles ivory as to merit the title of vegetable ivory. The plant (*Phytelephas macrocarpa*) which produces this nut belongs to the palm-tribe. It grows in South America, and possesses extraordinary beauty. The stem is short, and lies along the ground, but from its crown issues a sheaf of light-green, pinnated leaves, like ostrich-plumes, which often attain a height of 30 or 40 feet. The fruit of the plant is as large as a man's head, and contains a number of nuts of rough, triangular shape, each being almost as large as a hen's egg. When fully ripe, the kernel of the nut is very hard and white, and hence the name phytelephas (*vegetable ivory*). This is now largely used as a substitute for elephant ivory, in the manufacture of buttons and various ornaments, and might easily pass for the animal product. Indeed, the best judges are often deceived by the close resemblance between the two. Advantage is taken of this circumstance in Germany by dealers in bone-dust to adulterate their wares with the waste of the factories where the vegetable ivory is manufactured. The best mode of detecting the adulteration is to burn the suspected article. If it contains any considerable amount of the vegetable substance, the application of heat will cause it to give out an odor much like that of roasting coffee; but, if it is pure bone-dust, or nearly so, it will emit a nauseous and very disagreeable stench.

Coloring Matter in Blood.—A writer in Virchow's *Archiv* finds in blood two distinct coloring-matters. One of these is readily soluble in water and alcohol, but not so readily in ether. When dry it has a dark, greenish-brown color, and is carbonized on the application of heat, without ebullition. The ash is strongly colored with iron, and contains phosphoric and silicic acids, and a trace of alkali. It does not yield hemin-crystals under any treatment. With guaiacum-tincture and turpentine-oil it gives the well-known blue color, and under the spectroscope is found to possess the characters attributed to alkaline oxyhematin by Preyer. It appears to be identical with Von Wittich's hematin. The other coloring-matter consists of dark, blue-black microscopic crystals, insoluble in water, alcohol, ether, chloroform, and acids, but soluble in weak alkaline solutions, to which they give a brownish tint. If it be then precipitated by acetic acid, and dried, it will, on being treated with sal-ammoniac and glacial acetic acid, yield beautiful hemin-crystals. When reduced to an ash, it consists of pure oxide of iron. It seems to be identical with Virchow's hematoidin.

Elimination of Carbonic Acid by the Skin.—The amount of carbonic acid given out of the system through the skin in man has been variously estimated by physiologists; but, as their methods of determination were all more or less defective, it is not surprising that their results should differ very considerably from one another. Thus Reinhard's estimate makes the average daily elimination of carbonic acid through the skin about 35 grains, while Gerlach makes it 120 grains; other authorities ranging all along between these two extremes. A special apparatus has been devised by Dr. Aubert, of Rostock, for more accurately ascertaining the amount of this excretion. He seats a person within a box, which fits lightly around the neck, and through which a gentle current of air is passed. Dr. Aubert, in this way, finds that in the course of 24 hours a maximum of 97 and a minimum of 35½ grains of carbonic acid are eliminated by the skin of the whole body, exclusive of the head. Variations of temperature will of course affect the amount of carbonic acid thus excreted. In the experiment, the external temperature was about 86° Fahr.

Remarkable Diamonds.—A diamond was recently discovered, at the Cape of Good Hope, which weighs 288 carats. This the

Builder calls enormous, and accordingly christens the new stone "Queen of Diamonds." But the *Builder* is plainly in error here, for there are many diamonds which weigh far more. Thus, the Grand Mogul is the owner of a rose-diamond which, in the rough state, weighed 780½ carats. It lost very largely in the cutting, weighing now only 136¾ carats. It is valued at over two and a quarter millions of dollars. A potentate in Borneo owns a diamond weighing 367 carats. The "Regent" weighed in the rough 410 carats. The "Orloff" weighs 194¾, and may have weighed thrice as much in the rough state. An Austrian diamond weighs 139½, and, as the lapidary cannot cut these stones without depriving them of at least half their weight, it must have been, in the rough, larger than the Cape "Queen." But the name given to this newly-found stone will appear still more incongruous when we consider its quality. A diamond is said to be of the first water when it is perfectly limpid and colorless, and free from flaws, and of the second or third water in proportion as it departs from this standard. But this Cape diamond is of a yellow color, and marked with flaws—it is, therefore, not of the *first water*, and would in all probability be classed by the lapidary as of the *third water*.

Production of Sea-Salt in Portugal.—The salines of Portugal, at Setubal, Lisbon, Aveiro, and Algarve, yield annually 250,000 tons of sea-salt. According to Prof. Wauklyn, in the *Mechanics' Magazine*, the process of manufacture at the first-named place is as follows: There is a vast reservoir of about four acres in extent, eight inches deep, and partitioned into squares of about 130 yards in surface. Roads, three feet wide, separate the squares, and the latter all communicate with the main reservoir of sea-water. In autumn the whole salt-marsh is overflowed to the depth of 20 inches. This water evaporates in the spring, the roads appearing above the surface in June. Then the tanks are cleaned out, and afterward left to themselves, and recharged from time to time with new supplies of water. In 20 days a layer of salt over one inch thick is found. This, the first crop, is collected, and the tanks filled again. In 20 days another crop is gathered. If the season is favorable, three crops may thus be collected before September, when the marsh is flooded for the winter.

Controlling Sex in Butterflies.—The *American Naturalist* for March contains an admirable essay by Mrs. Mary Treat, in which she brings a long array of facts to prove that the sex of butterflies depends, in some cases at least, rather upon the external conditions surrounding the larva, or caterpillar, than on its anatomical structure. The results of the author's experiments contradict the doctrine of most entomologists, which asserts that even in the eggs of the *Lepidoptera* the germs of sexual difference may be discerned. The editor of the *Naturalist* quotes from several authorities, to show that, in the case of all animals which reproduce by eggs, the sex is probably determined at or about the time of conception, or at least early in the embryonic stage. Mr. T. W. Wonfor also, writing on "Certain Wingless Insects," in *Hardwicke* for March, asserts that the very same conditions, viz., lack of abundant food, or alternations of scanty and bountiful food, which, according to Mrs. Treat's experiments, determine the sex of the future imago, or butterfly, tend only to "produce dwarfs or monstrosities." The writer in *Hardwicke*, we may add, holds that no sex-difference is discernible either in the eggs or in the larvæ. Mrs. Treat's observations and experiments, it will be seen, were very thorough-going and very carefully conducted, and will, doubtless, attract the earnest attention of naturalists. Some two years ago Mrs. Treat placed a larva, which had already taken some steps toward the chrysalis state, upon a fresh stem of caraway, and was surprised to see it commence eating. It then continued to eat for some days before changing to a chrysalis. She next placed a number of other larvæ on similar stems of caraway, while still others she deprived of food altogether. Those of the last lot which completed their transformations were all males, and all the butterflies from the first lot were females.

The next experiment was commenced in June last. In July the author had about two hundred larvæ feeding at once. Im-

mediately after the last moult, a number of these were shut up in paper boxes, five to ten in a box, and deprived of food. If, two or three days after confinement in the boxes, any of the larvæ were found wandering about, they were fed very sparingly. Nearly all of them lived to complete their transformations. Another lot were, in like manner, put in boxes, but supplied with abundant food. From the latter came sixty-eight females and only four males; from the former seventy-six males and only three females. Five larvæ that were eating vigorously were also taken from their food a day or two before they would have been sated. Of these, four turned out females.

Another experiment was this: Soon after the last moult, twenty larvæ were deprived of food for twenty-four hours. Then ten of them were given abundant food again, as long as they would eat. One of these met its death by accident in the chrysalis state, but all the rest became female butterflies. Of the other ten, two died in the chrysalis state; the remainder were males.

Again: Some twenty half-grown larvæ of the *Vanessa antiopa* were accidentally deprived of food. Twelve of them died of starvation, but the remainder completed their transformations. On dissection, these eight all proved to be males. The indefatigable student pushed her investigations further still, for, having found thirty-three larvæ of an unfamiliar species, she fed them abundantly, till they would eat no more. The rare and beautiful moth *Dryocampa rubicunda* made its appearance in due time, and there were twenty-nine females and only two males, the remaining two having either escaped or died. Finally, a lot of the same species of caterpillars were left without food. Some of them were killed by a parasite, others died of starvation, and the seven which survived were all males.

Hydrophobia and the Imagination.—The period of time which elapses between the bite of a rabid animal and the appearance of hydrophobic symptoms varies over a very wide range indeed. The disorder seldom makes its appearance earlier than the eighth day after inoculation (if inoculation there be); or, again, the virus may be hidden in the wound for weeks, months, or even years. Physicians say that, in most cases, hydrophobia manifests itself in from four to eight weeks after the bite, though there are many authentic cases where the period of incubation extended over eight or nine months, and in one instance even as long as seven years. In this term *incubation* is implied an hypothesis gratuitously assumed, and scarcely susceptible of direct demonstration. It is found that a patient bitten by a rabid animal passes a certain length of time without manifesting hydrophobic symptoms, and it is supposed that the germs of the disease have been slowly maturing. But, as there is no other disease whose period of incubation is so long or so varying in duration, the hypothesis which traces hydrophobia to animal virus finds no foundation in analogy, and is consequently very weak.

It is, therefore, very natural that medical men should begin to study the whole question anew, and attempt other explanations of this disease. Thus, Dr. D. H. Tuke, whose paper on the "Blanching of the Hair" appeared in our December number, has lately published a work on the "Influence of the Mind upon the Body," and there supports the proposition that hydrophobia is produced solely by the action of the imagination. The author cites cases where, beyond all doubt, hydrophobic symptoms were developed without inoculation. A notable instance is that of a physician of Lyons, named Chomel, who, having aided in the dissection of several victims of the disorder, imagined that he had been inoculated with the virus. On attempting to drink, he was seized with spasm of the pharynx, and in this condition roamed about the streets for three days. At length his friends succeeded in convincing him of the groundlessness of his apprehensions, and he at once recovered. Rush also tells of cases of spontaneous hydrophobia, which arose from no other cause but fear and association of ideas.

A German physician, too, Dr. Marx, of Göttingen, as we learn from the *Clinic*, is disposed to take this view of hydrophobia, and to regard it as a psychical affection, the result of morbid excitement of the imagination. He is of the opinion that the bite of a mad dog does not, of itself, produce

the symptoms of hydrophobia, and that, were it not for the common belief in canine virus, the spasms and other manifestations of the disease would not supervene. This view is confirmed by the fact that young children, who are not acquainted with the common belief as to hydrophobia, may be bitten by mad dogs and escape spasms and madness. He adds:

"If we are able, as in olden times, and in the case of children, to instruct or induce men to be perfectly quiet after they are bitten by a rabid dog, not to tremble or be frightened, but to banish anxiety, to control their imagination, and, with patience and hope, to look forward to recovery, and also to persuade the well to remain with the unfortunate one, and not to run away, but to cheer him in the hour of trial, then the means may have been discovered by which the effects of the accident are to be banished, and the poison in the wound neutralized."

Odorous and Liquefiable Gases: what Gases may be liquefied.—A writer in the *Pharmaceutical Journal* notes a remarkable relation between the odor of gases and their reducibility to the liquid or solid state. Thus oxygen, hydrogen, and nitrogen, which have no odor, cannot be reduced either by pressure or by cold. On the other hand, chlorine, which has a very strong odor, is easily condensed to a liquid. Again, the protoxide of carbon, being odorless, cannot be condensed, while the dioxide or carbonic acid, which has a faint, pleasant, and pungent odor, can be reduced to a liquid, and even to a solid state. Nitrous and nitric oxide, the latter of which is odorless, show similar phenomena. An exception to the general rule, that gases which are odorous are condensible, is furnished by acetylene, which, though having a faint garlic smell, has never been condensed. Usually condensibility stands in a direct ratio to the strength of the odor possessed by a gas. Thus, sulphurous acid, which has a most intense odor, becomes a liquid under a pressure of two atmospheres, at 15° Fahr., while nitrous oxide, which has but a faint smell, requires fifty atmospheres, and a temperature of 7.2° F. A few gases having a fetid odor are exceptions to this law, but it holds good so generally, that a list of gases, arranged according to their reducibility, and another list arranged according to their properties of smell, will show a rough though marked coincidence.

The Spectroscope and the Bessemer Process.—Prof. Tidy, in a lecture on the spectroscope, thus briefly describes its important practical application in the Bessemer process: "Cast-iron contains a great amount of carbon, and in the Bessemer process this carbon is got rid of by burning it out of the molten iron with a blast of atmospheric air. The fluid cast-iron is placed in a large retort lined with refractory clay. This retort, the *converter* as it is called, turns on a pivot. Through the pivot a tube passes in connection with a very powerful blowing apparatus, by which air can be blown into the molten iron. That air burns out the carbon, the heated gases issuing as a flame from the converter. Now, it is very important to stop that blowing process directly the time arrives. Ten seconds too soon, or ten seconds too late, and the charge is spoilt. Experience, I grant you, does guide the worker, but experience is a costly thing; and this I am confident of: laud experience as you will, it will not weigh down the scale when we have in the opposite pan exact scientific experiment. The Bessemer flame, as it issues from the converter, is examined by the aid of the spectroscope. Numerous substances are visible—sodium, potassium, iron, hydrogen, carbon, etc. All of a sudden, in a second, the carbon-lines disappear, and that is the moment when the air-blast must be turned off, for now the carbon is burnt away, and the iron is converted."

New Material for Illuminating Gas.—*Le Gaz*, the gas-light journal of Paris, calls the attention of the directors of gas-works to a new illuminating material, *vegetable pitch*. This material is made by the Patent Oil and Stearine Company, of England, from the residues of the manufacture of olive, palm, cocoa, and other oils. In England it is widely used, being employed in gas-works in connection with coal, with a view to augment the volume of gas, as well as its illuminating power. The London Gas-light Company constantly employs it, mixing it in

certain proportions with the coal, and the Gas Company of the Crystal Palace uses this material only, to produce a rich gas. The pitch is solid and glistening, and distils very rapidly in the common gas-retorts, leaving scarcely any residue. In case a large amount of gas is required to be furnished in a very short time, this property of rapid distillation is of high importance. Its yield of gas is said to be very considerable, being 765 to 850 cubic metres (830 to 930 cubic yards) to the ton. The illuminating power of this gas is equal to that of 33 sperm-candles, 5 to the pound. It is too rich to be used with the ordinary burner. It is best employed to enrich gas made from inferior coals. It contains scarcely any sulphur—0.87 per cent. The analysis of the pitch is as follows: Volatile matter, 74.40; fixed carbon, 21.72; ashes, 3.88.

Antiquity of Man.—The following letter from Sir John Lubbock appeared in *Nature* for the 27th of March: "I have received a letter from Mr. Edmund Calvert, in which he informs me that his brother, Mr. Frank Calvert, has recently discovered, near the Dardanelles, what he regards as conclusive evidence of the existence of man during the Miocene period. Mr. Calvert had previously sent me some drawings of bones and shells from the strata in question, which Mr. Busk and Mr. Gwyn Jeffreys were good enough to examine for me. He has now met with a fragment of a bone, probably belonging either to the dinotherium or a mastodon, on the convex side of which is engraved a representation of a horned quadruped 'with arched neck, lozenge-shaped chest, long body, straight fore-legs, and broad feet.' There are also, he says, traces of seven or eight other figures, which, however, are nearly obliterated. He informs me that in the same stratum he has also found a flint flake, and several bones broken as if for the extraction of marrow. This discovery would not only prove the existence of man in Miocene times, but of men who had already made some progress, at least, in art. Mr. Calvert assures me that he feels no doubt whatever as to the geological age of the stratum from which these specimens are obtained. Of course I am not in a position myself to express any opinion on the subject, but I am sure that the statements of so competent an observer as Mr. Calvert will interest your readers."

NOTES.

THE population of France, as shown by the census, was 38,067,064 in the year 1866. The official estimate of annual increase is 130,078—or, for the seven years ending January 1, 1873, 910,546. Total, 38,977,610. But the actual census gave only 36,102,921, showing a loss of 2,874,689. Deduct the official estimate of Alsace-Lorraine, 1,595,238, and the remainder, 1,279,451, represents the decline of population during seven years. The excess of females over males is now 100 per cent. greater than ever before.

THE epileptiform convulsions excited by the internal administration of essence of wormwood, and Japan camphor, may, according to recent experiments in France, be effectually prevented by the use of bromide of potassium. This is regarded as additional evidence of the value of the bromide in the treatment of epilepsy.

THE medical officer having under supervision the schools for pauper children in three of the parishes of London reports that, among those admitted, from thirty to forty per cent. are afflicted with ophthalmia in some of its stages, and that bringing the children together in this way concentrates and favors the spread of the disease. The immediate cause of the affection in most of these cases is held to be the dirt and dust of the streets which is allowed to accumulate at the inner corner of the eye, where it forms a semi-solid mass which irritates and inflames the lids.

DIED, in Jersey City, on Sunday, March 9th, CHARLES F. DURANT, aged 68 years. Deceased was a diligent student of science, and some years since published a valuable work on the "Shells and Sea-Weeds of the Harbor of New York." He was also the author of a work on astronomy, which was printed for circulation among scientific men. In 1833 Mr. Durant made the first balloon ascension ever made in this country. His aërial voyages numbered in all fifteen.

PETROLEUM has been found in large quantities in Ecuador. Wells have been sunk at various points between the sulphurous springs of San Vicente and the sea-shore. In some of these the petroleum is fluid, like whale-oil, but in others it has the consistence of butter. In the upper part of some of the wells it can be seen in hard, compact masses, which probably have been formed by the evaporation of the more liquid portions.

MR. WILLIAM YATES has made the following important modifications in the Davy lamp: He dispenses with wire gauze immediately around the flame, replacing it in front with a strong lens, and behind with a silver reflector. The miner cannot raise the flame so high as to heat the gauze, and, if he would open the lamp, to light his pipe, he is foiled, for that cannot be done, without extinguishing the flame.

A CORRESPONDENT of the *Lancet* tells of a hen laying a pair of eggs of good average size within the space of ten minutes. The same writer found in his poultry-yard a double egg, or two eggs combined. This is not a case of merely double yelk within one shell, which is common enough, but of two complete eggs, with separate shells entire, except at the points of contact.

IN Russia the sunflower is cultivated for the oil which it yields. This oil is used in cooking as well as for lamps, for soap-making, and for making paints. Fifty bushels of seed may easily be grown on an acre of land.

AT a recent meeting of the French Academy a magnet was exhibited by M. Jamin which carries more than thirty-two times its own weight, whereas the greatest carrying power hitherto obtainable in artificial magnets has been not above four or five times their weight. Instead of the thick plates usually employed, M. Jamin's magnet is made up of a number of very thin plates superposed on each other, and all thoroughly magnetized. By this contrivance the volume and weight of magneto-electric machines can be very considerably reduced.

IT has been shown by M. Bérard that, when fruits are set in the open air or in oxygen gas, a certain volume of oxygen disappears, and at the same time a nearly equal volume of carbonic-acid gas appears in its place. If, however, the fruits are placed in carbonic acid or any other inert gas, there is still produced a notable quantity of carbonic acid, as though by a kind of fermentation; and, since, under these conditions, the oxygen necessary to the change is not furnished by the surrounding medium, it must be supplied by the saccharine matter of the fruits themselves, a considerable part of which is thus transformed into alcohol.

A FRENCH horticulturist has perceived that, wherever a fruit—a pear, for instance—rested upon some branch or other support beneath it, that fruit always grew to a large size. The support given to the fruit permits the sap-vessels of the stem to remain open, and the fruit can receive abundant nourishment. Mr. Thomas Meehan made substantially the same observation some years ago.

EIGHTEEN men and 63 women died during the past year in England at the age of 100 years or over. There were still living, when the census was taken, 6 men and 22 women, 100 years old; 1 man and 14 women, 101 years; 3 men and 11 women, 102 years; 2 men and 6 women, 103 years; 5 men and 7 women, 104 years; 2 women, 105 years. A woman died in Huddersfield at the age of 107, and a man in Staffordshire was 108 years old when he died.

ON the American Continent, the *Sequoia*, or Big Tree of California, can find a congenial home only in a very few localities. In England, however, it appears to thrive admirably, and various "improved" varieties have already made their appearance there. The *Weeping Sequoia* is the latest novelty.

THE ancient Egyptians possessed the art of so tempering bronze that it would take and keep a sharp edge. Sir Gardiner Wilkison found in tombs bronze daggers which were almost as elastic as steel, after having been buried 3,000 years.

NICKEL ORE has been found cropping out in the counties of Madison, Iron, and Wayne, Missouri; and at Sand Prairie, in the same State, a new lead-mine has been discovered. The prospectors, says the *Iron Age*, took out 4,000 pounds of the mineral three hours after the lead was struck.

ONE of the chief potato-growing provinces of Holland, Groningen, has thirteen mills devoted to the conversion of potatoes into flour. Nearly the whole crop of the province is thus disposed of, the daily yield of the mills being some 246 tons of potato-flour. A large part of this, according to the *Glasgow Weekly Herald*, is consumed in the adulteration of wheat-flour in England.

ACCORDING to the French chemist Dumas, the newly-discovered art of decorating walls with tin-foil, bearing designs in oil-colors, has in a somewhat modified form been successfully practised by the Chinese for a long time.

A VEIN of plumbago, eight feet thick, has been discovered in Missouri. This is the first deposit of this useful mineral found in the West. The vein at Sturbridge, Mass., varies in thickness from one inch to two feet. There are also plumbago-mines at Brandon, Vt., Fishkill, N. Y., Wake, N. C., and St. John's, N. B.

FOUND *post mortem* in a lunatic's stomach: 44 pieces of shirt, 41 do. pocket-handkerchief, 10 do. caps, 8 do. braces, 7 do. chamber-pot handle, 6 do. stick, 5 do. leather, 4 do. coal, 3 do. stocking, 2 do. rag, 1 do. tobacco-pipe, 1 do. iron, 4 pebbles, 1 knitted cuff, 1 acorn. Total weight, over 8 lbs.

JOHN STUART MILL.